POWER PLANT ENGINEERING

Established Over 34 Years

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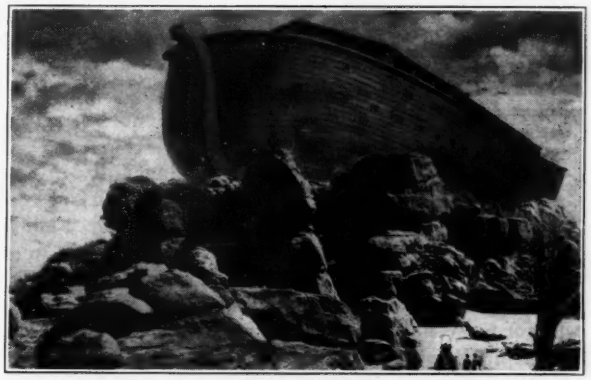


De-Lionizing the Ark

OLD NOAH, despite the fact he didn't have his hair bobbed, wasn't so slow. When he received a weather report to the effect that a big storm was coming he quickly built himself an ark in which he and his relatives played bridge until the country went dry. This much is an old story—every Sunday School teacher can tell you about it. Warner Bros. even took movies when the Ark docked at Hoboken.

What isn't known, however, is that Noah ran into a mess of trouble because of the lions. The lions, it seemed, being king of beasts, refused to bunk with the rest of the menagerie, in fact they demanded the royal suite. Naturally enough, this led to hard feelings, not to mention blows. Furthermore, Noah was parked in the royal suite himself and sided with the elephants, the crocodiles and whatnots. So the lions began to get rough and one morning just for meanness ate up a couple of Fizrumps for breakfast. That's why there are no Fizrumps in existence today. Another time they finished up the two Jabberumps.

Things went from bad to worse and one day, after the lions gobbled up the last two Slithy Toves on the map, Noah called a meeting of the board and it was decided unanimously to give the trouble makers the plank —in other words, they meant to de-lionize the ark. But this wasn't so easy. Before the excursion was over, the lions cleaned up a lot of other animals so Noah finally relinquished the royal suite and took a lower berth.

Noah, you see, was much in the predicament of the electrical engineer today. The electrical engineer is also concerned with an arc and for years he has been trying to deionize the arc, without success. Due to the *Lions* of force, so to speak, this has proved difficult and like Noah the electrical engineer almost concluded to let the lions of force have their way when along comes Dr. Slepian with a new plan for doing the trick. On page 282 you can learn all about it.

DESHLER HOTEL
Changes to Coal Burning

COLUMBUS, O., HOTEL ABANDONS GAS FOR BOILER FUEL IN FAVOR OF UNDERFEED STOKERS AND INSTALLS TWO 400-KW. ENGINE GENERATOR SETS FOR ELECTRIC POWER SUPPLY

CHANGING FUEL COSTS and operating conditions often necessitate remodeling of power plants and tax the ingenuity of the engineer. Such a change has been successfully accomplished in the Deshler-Wallick Hotel in Columbus, Ohio, where gas-fired boilers were changed to stoker firing and two 400-kw. engine generator sets installed to supply the electric power which was formerly purchased.

Originally the Deshler Hotel had its own boiler plant, all the necessary steam being supplied by four hand-fired Scotch marine boilers. The A.I.U., American Insurance Union, a 45-story building built several years ago, had a boiler plant consisting of three oil-fired 4150-sq. ft. Heine cross-drum boilers equipped with Peabody combination burners.

Recently the Deshler Hotel leased 18 floors of the A.I.U. building calling the original hotel and new annex the Deshler-Wallick Hotel. Inasmuch as the A.I.U. boiler plant was modern and in good condition whereas the boilers of the Deshler plant were old and being pushed to capacity, while the old boiler room space was badly needed for other purposes, it was decided to abandon this old boiler room and supply steam for both the A.I.U. building and the Deshler-Wallick Hotel from the A.I.U. boiler plant.

Because of comparative fuel costs, it was decided to change to natural gas firing and the boilers were equipped for this as shown in Figs. 2 and 3. The photograph shows both the oil and gas burners in place, oil being retained as a standby fuel.

Later a survey of the combined hotel and building load made it evident that by increasing the boiler pressure from 125 to 150 lb. it would be not only practical but economical to install generating equipment sufficient to take care of the electrical demands of both buildings. Still further study of the load conditions and fuel costs indicated that a change from gas and oil to coal was advisable.

As the boilers were already equipped with the Peabody burners, which would handle pulverized coal, this method of firing was considered. As shown in the boiler cross section, Fig. 2, combustion space was limited, the boilers installed in the sub-basement could not be raised and it was impractical to excavate additional furnace volume, so that it was felt stoker firing would be advisable in order to carry the necessary load.

Accordingly, Detroit UniStokers were installed as shown in the plant cross section Figs. 2 and 5. Both the oil and gas burners were left in place, with a course of firebrick in front of them to protect them from the fire. The stokers are installed under the other end of the boiler with bridge wall and baffle changes.

No provision had been made in the plant for coal

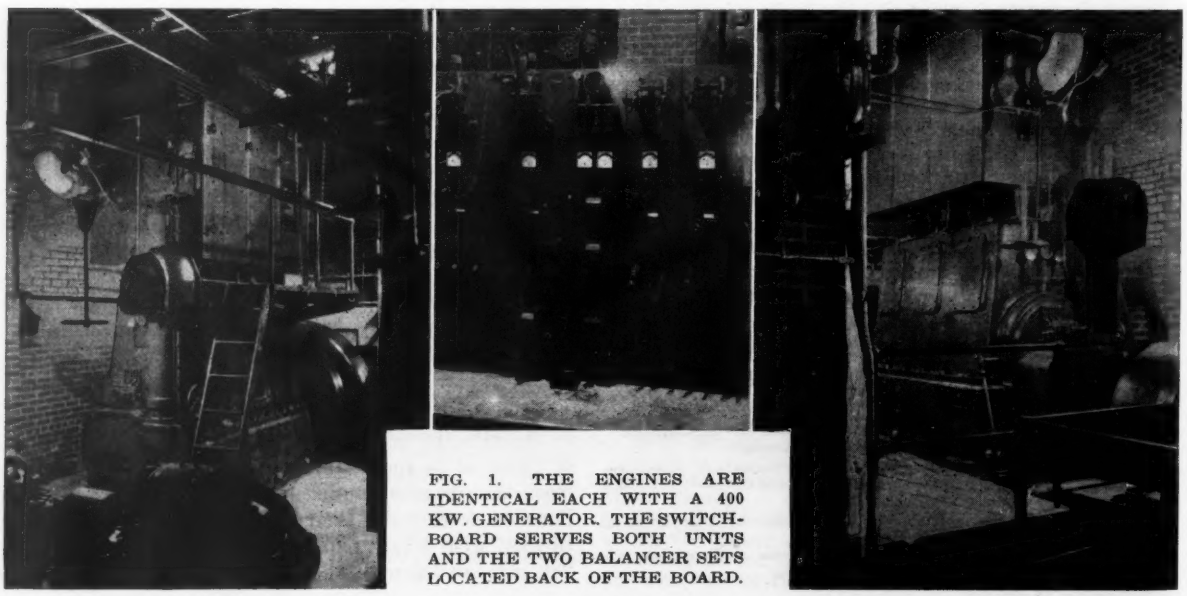


FIG. 1. THE ENGINES ARE IDENTICAL EACH WITH A 400 KW. GENERATOR. THE SWITCHBOARD SERVES BOTH UNITS AND THE TWO BALANCER SETS LOCATED BACK OF THE BOARD.

bunkers and owing to the limited span available the Jeffrey coal handling installation is quite unusual. The only available space for a coal bunker was under the sidewalk at right angles to and remote from the stokers. The 100-t. bunker shown in plan and section in Fig. 2 is built with a steel bottom sloping to conform to an 18-in. apron conveyor which discharges into a centrifugal discharge bucket elevator. The bucket elevator discharges into a 9-in. screw conveyor which in turn discharges into a second 9-in. screw conveyor at right angles to the first and parallel to the boilers. The second of these two conveyors passes over the stoker hoppers and discharges to them through rack and pinion valves.

Conveyors and elevator are driven by a General Electric 5-hp., 230-v. a.c. motor through a Jones speed reducer and bevel gears, while the apron conveyor is driven by a General Electric 3-hp., 230-v. d.c. motor through the same type of speed reducer. The coal handling capacity is 5 t. per hr. Coal is dumped through two sidewalk doors provided with a 2½-in. mesh grating for the sizing of coal. The doors, when open, form a chute for centering the coal in the opening.

As a safety feature, the end of the second screw conveyor is provided with an automatic stop mechanism, consisting of a flat plate within the conveyor trough connected by levers to an electrical circuit breaker. When the stoker hoppers are full and coal backs up in the spiral trough, pressure against the plate trips the mechanism and stops both motors.

Coal door and chute arrangement are shown in section AA Fig. 2. The apron conveyor, made up of $\frac{3}{16}$-in. double beaded flights 18 in. long with No. 10 ga. ends 4 in. high mounted on two strands of No. 126C malleable roller chain, has a speed of 10 f.p.m.; the bucket elevator made from 6 by 4-in. malleable iron buckets mounted on one strand of No. 88 detachable chain has a speed of 192 f.p.m. while the 9-in. dia. spiral conveyors, made of $\frac{3}{16}$-in. flights on 2-in. pipe have a speed of 45 r.p.m. All this equipment was furnished by The Jeffrey Mfg. Co.

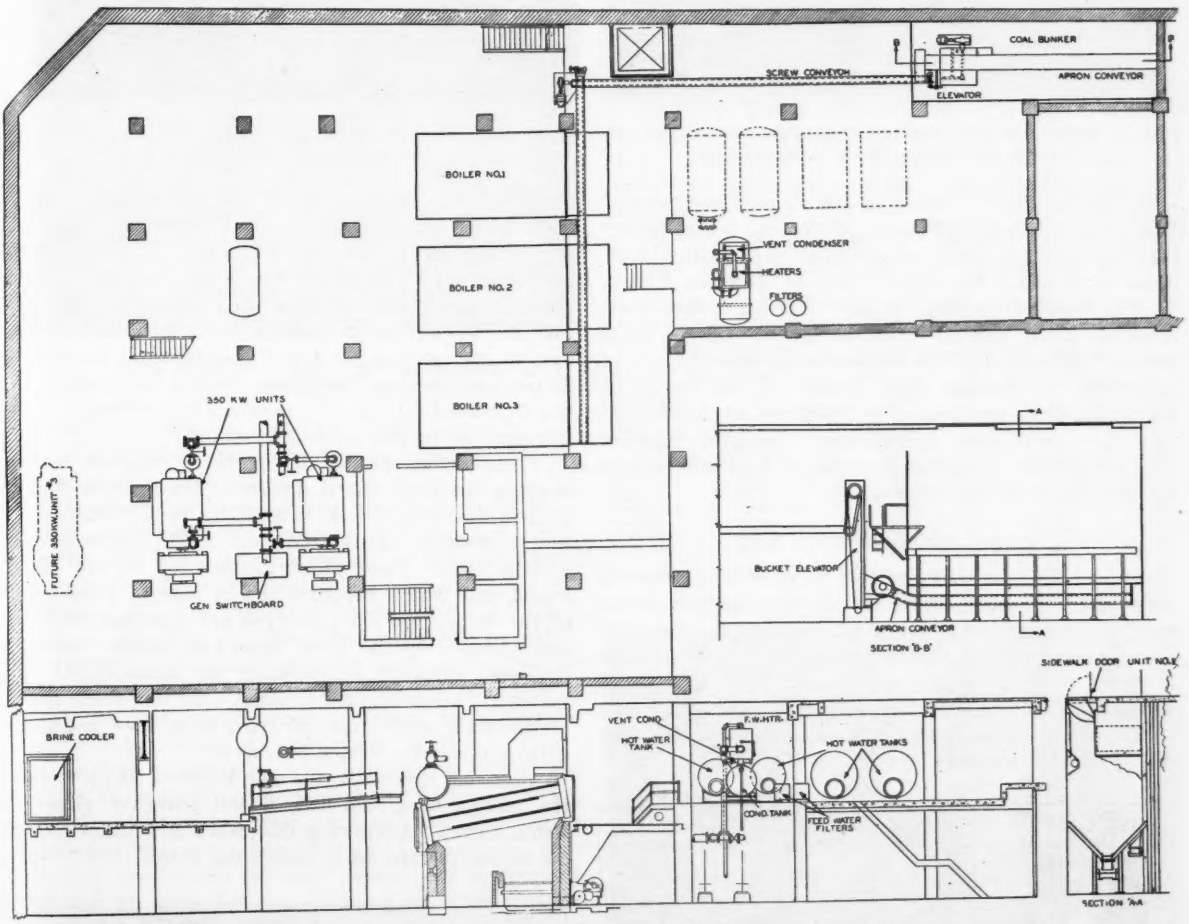


FIG. 2. PLAN AND SECTION OF THE POWER PLANT SHOWING THE INGENIOUS COAL HANDLING ARRANGEMENT

The three stokers, one of which is shown in Fig. 5, are Detroit UniStokers built with an integral forced draft fan. Combustion is controlled by a Hagan master controller. The Heine cross-drum boilers have a heating surface of 4150 sq. ft. made up of 233 3½-in. tubes, 18 ft. long. They are designed for a maximum pressure of 165 lb. and are now operating at 150 lb. pressure. They are equipped with Ashton safety valves, Golden Anderson automatic stop and check valves, Copes feedwater regulators and Bayer soot blowers.

Generating equipment consists of two Skinner 3-cylinder, vertical unaflow engines, driving Crocker-Wheeler, size 209-DA, 400-kw., 250-v., d.c., type CCD

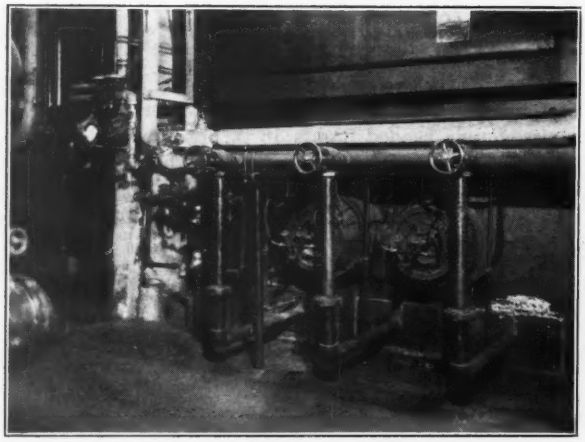


FIG. 3. GAS AND OIL BURNERS WERE LEFT IN PLACE WHEN STOKERS WERE INSTALLED

FIG. 5. ONE OF THE BOILER FRONTS TAKEN THE OPPOSITE SIDE FROM FIG. 3

compound-wound generators at 360 r.p.m. Two General Electric 1500-r.p.m., 200-amp., 250/125-v., 3-wire rotary balancer sets are used, connected as shown in Fig. 8. Space is provided for a third unit as shown in Fig. 2.

The three-wire system is used with all motors operating at 230-v. and all lights at 115 v. Of the three methods of securing the three-wire system the use of balancers was decided upon because of the degree of regulation they provide. The balancer set consists of two 115-v. machines mechanically connected together with armatures connected in series and connected into the generator unit as shown.

Peak Load Around 500 Kw.

It will be seen that the two balancer armatures in series are connected across the 230-v. generator armature. A connection is taken off between the two balancers armatures and this is connected to the center line of the three-wire distribution system. With a balanced condition, this set simply runs as two 115-v. motors in series but in unbalanced loads, they act automatically to supply the necessary current in the middle wire.

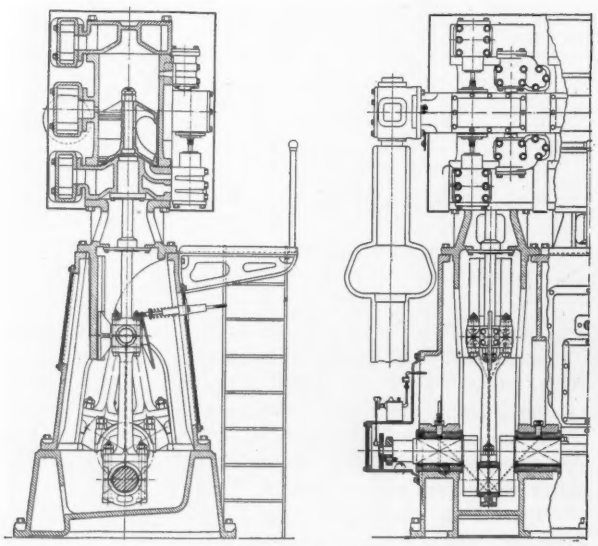


FIG. 4. CROSS SECTION AND DESIGN DETAILS OF THE VERTICAL ENGINES

The main requirement of this installation is that there be no light flicker under any condition of load, an interesting accomplishment when it is considered that the total load of about 500 kw. is made up of about 60 per cent power and elevator load. There are 14 elevators and the swings at times approximate 200 kw. Generators are rated at 40 deg. C. temperature rise with a 50 per cent overload for 30 min. with a temperature rise not to exceed 50 deg. C.; momentary overloads of 100 per cent are carried without sparking.

Construction details of the three cylinder vertical engines, the most recent design of the Skinner Engine Co. are shown in Fig. 4. The 15 by 14 in. cylinders are cast separately. Each cross head guide is cast integral with a spacer piece which is mounted on top of the frame and which supports the cylinder. Inlet valves of the double beat, poppet type are mounted vertically and operated by flat faced cams and rollers. Constant lead and constant compression are maintained. The valves are operated by two cams. One cam shaft, geared to the main shaft and operating at a fixed angularity with it, opens the admission valves.

A second cam shaft, the angularity of which is under the control of a four-ball, flyball governor, closes the steam valves. Advancing this cam shaft makes the cutoff earlier, retarding it makes the cutoff later. Auxil-

FIG. 6. THE SWITCHBOARD IS ON A BALCONY BACK OF THE ENGINES

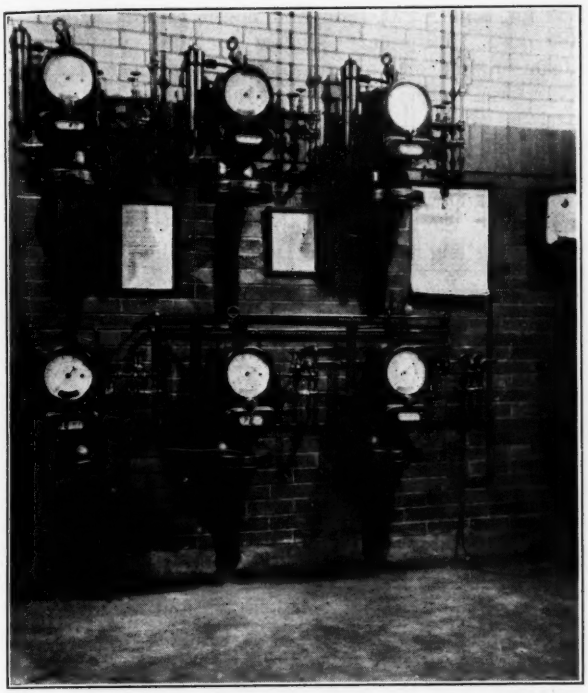


FIG. 7. FLOW METER PANELS IN THE ENGINEER'S OFFICE

iary exhaust valves are of the single beat type. A manually-operated speed changer is mounted on the side of the governor case.

In addition to the usual hotwater heating, building heating, compressed air, vacuum sweeping, air conditions, laundry and pumping services of a modern hotel and office building, the load consists of 5 Brunswick-Krochelle CO_2 refrigeration units totaling 165-t. capacity: one 45-t. and two 20-t. units in the A.I.U. building and one 30 and one 50-t. unit in the Deshler Hotel. They are all steam driven with the exception of one of the 20-t. units which is driven by a General Electric 50-hp., 230-v. d.c., 850-r.p.m. motor.

Electrical distribution is handled through the 16-panel black slate switchboard shown in Fig. 6 which served the plant when power was purchased. The engine switchboard shown in the center of the headpiece consists of 5 panels, one for each engine, one instrument panel and one panel for each balancer set. The plant is well equipped with instruments, Figs. 7 and 9 showing the Bailey electric type flow meter and instrument

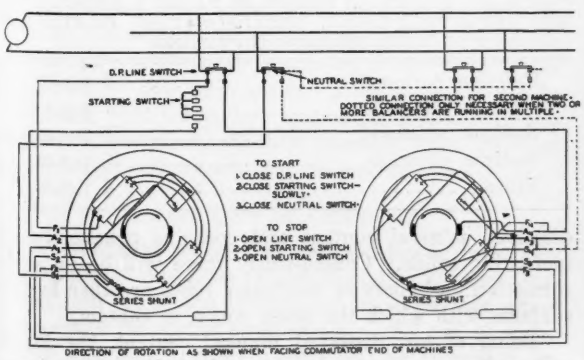

D.P. LINE SWITCH
STARTING SWITCH
NEUTRAL SWITCH
SIMILAR CONNECTION FOR SECOND MACHINE; DOTTED CONNECTION ONLY NECESSARY WHEN TWO OR MORE BALANCERS ARE RUNNING IN MULTIPLE.
TO START
1-CLOSE D.P. LINE SWITCH
2-CLOSE STARTING SWITCH-SLOWLY-
3-CLOSE NEUTRAL SWITCH
TO STOP
1-OPEN LINE SWITCH
2-OPEN STARTING SWITCH
3-OPEN NEUTRAL SWITCH
SERIES SHUNT
SERIES SHUNT
DIRECTION OF ROTATION AS SHOWN WHEN FACING COMMUTATOR END OF MACHINES

FIG. 8. WIRING ARRANGEMENT OF THE BALANCER SETS

TABLE I. WELL OVER 100,000,000 LB. OF STEAM IS USED EACH YEAR FOR HEATING AND HOT WATER SERVICE

Heating Load	Thousands of Pounds of Steam per Year
A. I. U. building heating	11,110
Ballroom heating	2,800
Deshler-Wallick heating	24,000
Deshler heating	25,200
Hot Water, Deshler-Wallick	18,000
Hot Water, Deshler	18,000
Kitchens, etc.	12,000
Total per year, thousands of lb.	111,180

panels in the office of the chief engineer. Feedwater is metered by a Venturi meter.

Studies made during the course of the investigation showed the quantities of steam used as given in Table I. From these figures, based on metered steam demand to the hotwater and laundry service to the Deshler-Wallick Hotel, and experience tables the steam demand per month for both hotel and office building was calculated as shown in Table II.

Based on gas bills for 1928 and the loads mentioned the cost of gas for fuel would have amounted to about

TABLE II. VARIATION OF THE STEAM LOAD BY MONTHS

Month	High Pressure Steam for Laundry, etc. Month - M.	Low Pressure Steam for hot water Month - M.	Low Pressure Steam for heating Mo.-M.	Total M.
January	1000	3000	14,500	18,500
February	1000	3000	11,400	15,400
March	1000	3000	9,500	13,500
April	1000	3000	5,695	9,695
May	1000	3000	1,280	5,280
June	1000	3000		4,000
July	1000	3000		4,000
August	1000	3000		4,000
September	1000	3000		4,000
October	1000	3000	3,780	7,780
November	1000	3000	8,240	12,240
December	1000	3000	8,785	12,785
Total M.	12000	36000	63,180	111,180

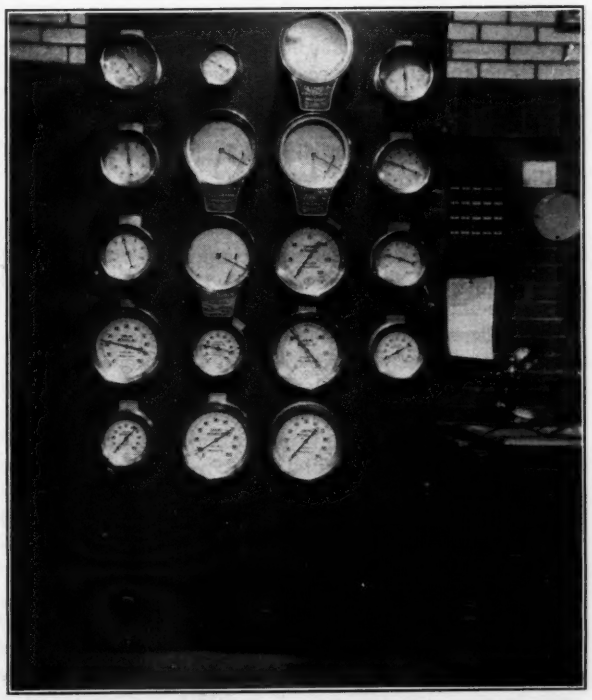


FIG. 9. PRESSURES AND TEMPERATURES ARE CLOSELY WATCHED

$0.666 per thousand pounds of steam against $0.238 per thousand for coal. This is fuel costs only, using gas at 40 cents per thousand cu. ft. and coal at $4.50 per ton. Additional fixed charges, on the coal burning equipment investment of about $35,000, and extra labor would increase the above coal costs $0.063 per thousand pounds of steam. These fixed charges were figured at 6 per cent for interest and 5 per cent for depreciation.

Electric load runs around 2,622,000 kw-hr. per yr. Peak loads are: Deshler-Wallick lights 200 kw., power 284 kw. and A.I.U. light and power 50 kw., a total of 485 kw. Preliminary studies included various size steam engine combinations as well as the use of a 375-kw. Diesel engine for carrying the summer load during periods when all the exhaust from the steam engines could not be used.

L. C. Wallick is president, A. L. Wallick, vice-president and general manager; J. H. Michel, resident manager; G. C. Sayles, chief engineer, and Samuel R. Lewis, consulting engineer of the Deshler-Wallick Hotel.

Boiler Feed and Cooling Pond Water Treatment

LIME AND ALUM, RECARBONATION, FILTERING AND ZEOLITE TREATMENT, IN PROPER COMBINATION, PROVE ECONOMICAL IN MUNICIPAL PLANT. BY A. C. EMBSHOFF*

SERIOUS DIFFICULTY was experienced at a municipal water and light plant due to scaling of surface condensers and boiler tubes with consequent loss in operating efficiency. Boiler feed make-up water amounted to 30,000 gal. per 24 hr. and the condenser cooling pond make-up requirements about 200,000 gal. per 24 hr. The source of supply is a river. The following analysis, Table I, shows the average character of this supply.

TABLE I. ANALYSIS OF THE WATER SUPPLY

Calcium carbonate	197 p.p.m.
Magnesium carbonate	45 p.p.m.
Magnesium sulphate	60 p.p.m.
Sodium sulphate	3 p.p.m.
Sodium chloride	16 p.p.m.
Silica	7 p.p.m.
Suspended matter	110 p.p.m.

After careful study, the recommendation was made that all of the water, 230,000 gal. per day, be treated with lime and alum for coagulation and the removal of the temporary hardness, the treated water then recarbonated with carbon dioxide and the lime treated and recarbonated water then filtered and passed through a zeolite water softener.

REASONS FOR RECOMMENDATIONS

Being from a river, the water supply always contains more or less turbidity and suspended matter, the amount present being greatly increased immediately after heavy rains. Consequently coagulation and sedimentation previous to filtering are essential for the economical removal of the suspended matter and turbidity. Since a sedimentation tank having holding time of at least four hours is a necessary part of a cold process lime softening plant, the installation of a plant of this type not only provides for the removal of the greater portion of the carbonate hardness by lime treatment but also provides for coagulation and sedimentation of the water.

Treatment of the water with lime and alum reduces the carbonate or temporary hardness from 242 to approximately 40 p.p.m., and the heavy floc formed as the result of the lime and alum treatment carries down with it very effectively such turbidity and suspended matter as may be present. Consequently, the water after this treatment will have a much smaller dissolved mineral content and will be practically clear.

FLUE GASES USED FOR CARBONATING THE WATER

The lime treated water is then passed through a carbonating tube in which it is brought into intimate contact with carbon dioxide gas. The carbon dioxide is obtained from the plant flue gases, these gases being passed through a scrubber and dryer to remove dust, tar and other objectionable substances from them previous to their introduction into the water. The treatment with carbon dioxide converts the unstable, slightly soluble calcium carbonate remaining in the water after the lime treatment to the highly soluble and stable calcium bicarbonate, thereby preventing possible difficulty from after precipitation of the unstable calcium carbonate.

If the water were not recarbonated, precipitation of the unstable calcium carbonate would occur in pipe lines and since the lime treated water is to be passed through a zeolite softener, any precipitation must be prevented or the zeolite mineral would become coated and rendered inactive and useless.

After recarbonation, the water is filtered through sand filters, the filtered water then being passed through a zeolite softener for the removal of the carbonate hardness remaining in the water after the lime treatment and the sulphate hardness, which is not reduced by the lime treatment.

Water thus produced, see the analysis Table II, is free from suspended matter and turbidity, has a low dissolved mineral content and contains practically no incrusting solids. Consequently there will be no scale formation on boilers or condenser tubes or other heated surfaces with which the water comes in contact.

TABLE II. WATER AS SHOWN IN TABLE I AFTER LIME AND ALUM TREATMENT, RECARBONATION, FILTRATION AND ZEOLITE SOFTENING

Calcium carbonate	8 p.p.m.
Sodium carbonate	37 p.p.m.
Sodium sulphate	74 p.p.m.
Sodium chloride	16 p.p.m.
Silica	4 p.p.m.

Being of low dissolved mineral content, the boiler and cooling pond blowdown required to maintain any

*International Filter Co.

desired concentration in boilers or cooling pond is reduced to the minimum, thereby saving both heat and waste water in boiler operation and saving waste water in the cooling pond water.

Desirability for Cooling Pond Make-Up

Since the water contains practically no incrusting solids after zeolite softening, it may be recirculated and concentrated in the pond for an indefinite period before evaporation of the pond water will increase the hardness sufficiently to cause any difficulty from scale on the condenser tubes. Having been recarbonated, the water cannot cause any difficulty from after precipitation.

From a boiler feedwater standpoint, the treated water would have a sulphate carbonate ratio of approximately 2 to 1 sufficient, according to the A.S.M.E. boiler code committee, to prevent difficulty from caustic embrittlement, in boilers operating at 250 lb. pressure or less. If higher boiler pressures are encountered, further provision for preventing of possible difficulty from caustic embrittlement would have to be made by the addition of sodium sulphate or trisodium phosphate to the boiler feedwater.

Other Methods Considered Ideal for Requirements

Taking into consideration the character of the raw water, the treatment described provides an almost ideal water for the required services at minimum cost of treatment. Other methods of softening the water were given consideration before the method outlined above was adopted. Softening all of the water in a zeolite softener after coagulation, sedimentation and filtration as well as also softening all of the water by lime, soda ash and sodium aluminate were considered.

Clarification and zeolite softening were rejected because the water after such treatment would not be particularly desirable for boiler feed because of the relatively high dissolved mineral content and adverse sulphate carbonate ratio; although, of course, the softened water produced by this method would have been entirely suitable for cooling pond make-up. Its use for boilers and pond, however, would have necessitated a rather heavy blowdown from both to maintain a given concentration.

Softening by lime, soda ash and sodium aluminate was rejected because very careful chemical control would be necessary if the maximum benefits in both boilers and pond were to be obtained. The variable character of the river water made close control difficult. Properly treated, by this method, the water would have been entirely satisfactory for boiler feed. Due to the fact, however, that the hardness probably could not be consistently held below three grains per gallon with this method of treatment, absolute freedom from scale on the condenser tubes could not be guaranteed.

Lowest Cost of Chemicals

The treatment selected, as outlined herein, was open to none of the objections of the other two methods considered and while the investment involved was somewhat greater the cost of chemicals per 1000 gal. of water treated was less, thereby justifying the increased investment. Based on lime at $15 per t. soda ash at $35 per t.; sodium aluminate at $160 per t.; alum at $30 per t., and salt at $10 per t., all delivered to the plant, the cost of chemicals per 1000 gal. of water softened by the method selected is 3.9c; by the method of coagulation, settling, filtering and zeolite softening, 4.9c; and by the lime, soda ash and sodium aluminate, treatment 4.9c. On the basis of these figures, the saving in the cost of chemicals by the method selected amounts to about one cent per 1000 gal. or $2.30 per day or $840 per year. Capitalized at 15 per cent per year, this saving would justify an added investment of $5600 in the method selected; whereas the actual additional investment over the cheapest of the other methods was but $4000.

New Furnaces and Pulverizers at Cahokia*

By G. V. Williamson

As a part of the expansion program at Cahokia Station of the Union Electric Light & Power Co., St. Louis, Mo., new unit coal pulverizing mills have been installed under boilers No. 13 and 15. At the same time, the furnaces and method of firing have been changed so as to have two more boilers conform with the latest type of pulverized coal firing as it has been developed in later sections of Cahokia and at the company's Venice Station.

New mills were installed primarily to increase the coal pulverizing capacity of the plant. The monthly output of electrical energy from Cahokia has increased steadily from about 20,000,000 kw-hr. in 1924 to 90,000,000 for the coming season.

This has been made possible by adding generators, but the monthly output from two complete sections has increased from 40,000,000 kw-hr. in 1925 to 60,000,000 in 1929.

Need for more mill capacity for pulverizing coal has resulted and has been met by installing four mills under two second section boilers, with a milling capacity of 30 tons of coal an hour, or 15 tons an hour for each boiler.

Mills of a type somewhat different from those already in service have been installed. The newer design appeared to have some advantages over the old, particularly in lower maintenance and in a more uniform degree of fineness in pulverizing.

These points and the ability of the mill to grind coal such as is used at Cahokia were verified in the plant of the National Cash Register Co. at Dayton, Ohio.

Several carloads of Illinois coal were sent to that plant and through their courtesy it was possible to conduct tests with this type mill and determine its fitness for use under Cahokia conditions. The results were satisfactory and consequently the new design of mill was installed. The installation has been completed for some time and the performance has met all expectations.

The change to direct firing mills (the two boilers were formerly fired from a storage system in which coal is pulverized in another section of the plant) was also accompanied by a change to horizontal turbulent firing, the advantages of which have been thoroughly proven at Cahokia.

*From the Union Electric Magazine.

As a result of this change, the combined capacity of the two boilers has been increased from about 300,000 lb. steam per hour to 400,000. At the same time, severe trouble with ash slagging has been eliminated. When it is recalled that these boilers were originally installed in 1927, the rapid development in pulverized coal firing is indicated.

Boilers 13 and 15 were chosen because of their proximity to the direct fired boilers in the third section. Thus all the unit mills are kept together and it was a simple matter to extend the third section coal handling system so as to accommodate the new installation.

These two boilers were already equipped with water walls, forced and induced draft fans and air heaters. Furnace alterations were confined to the addition of a water-cooled hopper bottom and the change to horizontal burners.

Petroleum Coke—Its Utilization as Boiler Fuel

THIS BY-PRODUCT OF CRACKING STILLS MAKES A GOOD BOILER FUEL WHEN PROPERLY PREPARED FOR BURNING IN PULVERIZED FORM. BY M. E. SCHULTZ*

IN ORDER TO SUPPLY the increasing demand for motor fuel, an appreciable percentage of the gasoline now marketed is being produced by various cracking processes. After the straight run gasoline is removed from the crude oil by distillation in a topping or skimming still, the residual oil, or the heavier distillates

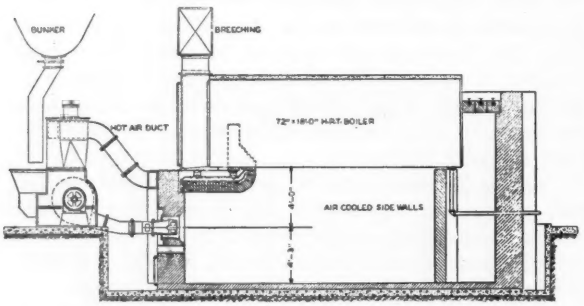


FIG. 1. SECTION THROUGH THE FURNACE AT THE PARAGON REFINING CO. PLANT IN TOLEDO

from this product (such as gas oil), may be made to yield additional gasoline, by subjecting these heavier fractions to higher temperatures or higher temperatures and pressures in the so-called cracking stills. This process is one of thermal decomposition and compounds entirely different in character from those contained in the original product are formed. Most cracking processes yield directly what is usually termed pressure distillate, together with some heavier fractions. The pressure distillate contains the recoverable gasoline, which is removed, usually after acid treatment, by distillation. The cracking process is also accompanied by the formation of fixed gases and carbon.

This latter product consists of carbonaceous particles cemented together by a sticky semi-solid asphaltic material. In most cracking processes now in use, an expansion tank, or reaction chamber as it is often called, is provided, in which most of this carbon is collected and subsequently removed at the end of the run by various devices. In some cracking plants, particularly those in which the heavier fractions of the crude are processed, a considerable amount of this carbon or petroleum coke, under which name it is usually marketed, is formed; in some cases as much as sixty pounds may be produced from every barrel of oil charged to the cracking still. A refinery cracking several thousand barrels of oil a day may, then, soon find itself with a large amount of this material on its hands unless a means of utilizing or disposing of this product has been provided.

Such was the case at the Paragon Refining Co. not long after two Dubbs cracking stills were put into operation, cracking 24 to 28 A.P.I. gravity still bottoms. Some of the coke produced was marketed through a local coal dealer as domestic fuel, but this demand was insufficient to take care of the amount being produced.

Due to the friable nature of this type of coke, in removing and subsequent handling of this product, a large percentage of braize is formed, rendering a large portion unfit for the ordinary use. Our problem was then to find a means of utilizing or disposing of the excess coke, particularly the large amounts of braize. Two methods suggested themselves; first, to make briquettes of the fine material and market them as a high grade domestic fuel, or second, to use the product ourselves in a powdered state. We tried burning this product in our stokers with little success; however, this is to be expected inasmuch as this coke contains but a small percentage of ash and affords little protection to the grates. This results in short life of grate bars. Even a small percentage mixed with coal caused trouble on the stokers; however, this method might have been more successful if adequate provision had been made to mix intimately these two products. Even if the trouble with rapid deterioration of the grates was corrected, the large percentage of fines would give rise to excessive sifting loss.

We conducted some experimental work relative to the possibility of making satisfactory briquettes for domestic use and secured some promising results. This would, however, entail a considerable initial investment and necessitate our entrance into a business with new and entirely different problems. Realizing this, we were reluctant to follow this course and devoted our time to the simpler solution, that is, using it as a pulverized fuel. Considerable experimental work is now being carried on by several of the larger companies on the briquetting of petroleum coke and some of the products have been marketed.

Two typical analyses of petroleum coke made in our cracking stills are given in the accompanying table.

Sample No. 2 shows an ash content considerably higher than No. 1. Some time after the first sample was taken, we started injecting a small percentage of hydrate of lime into the stills with the charging oil to

*Chief Engineer, Paragon Refining Co., Toledo, O.

decrease corrosion in the equipment and a considerable portion of this material is removed from the system with the coke, causing the percentage of ash to increase. In either case, however, it can be seen that this percentage is far less than the best grades of coal. The heating value of coke is of course consistently higher than coal.

Petroleum coke has certain properties, which are an asset when used as a powdered fuel. Since the ash content is extremely low, a boiler may be kept on the line a much longer time as far as ash removal is concerned and, being of a very friable nature, is pulverized much more easily than coal, resulting in lower power consumption and longer life of the crusher hammers. The

TYPICAL ANALYSES OF PETROLEUM COKE

	Sample No. 1	Sample No. 2
Moisture, %	0.24	0.375
Ash, %	0.78	1.90
Volatile matter, %	11.59	11.65
Fixed carbon, %	87.63	86.45
Sulphur, %	0.96	1.10
Heating value, B.t.u. lb	15,730	15,400

percentage of volatile matter in this product would indicate that there would be difficulty in keeping the flame ignited. While it is true that ignition does not take place as readily as some high volatile coals, with some few adjustments and precautions, there is no difficulty in maintaining a good flame. We are having gratifying results on our 150-hp. h.r.t. boilers, which should be one of the most difficult boiler applications.

It has been suggested that the structure of the particles must play a part in the flame propagation, where the percentage of volatile is small. It is conceivable, for example, that anthracite, regardless of how finely it may be reduced, consists of hard dense particles and that there is not sufficient volatile in the anthracite to open up the particles as the temperature increases, so as to render it more susceptible to oxidation. This may explain why anthracite is difficult to burn in pulverized form, requiring a greater degree of fineness and a much higher furnace temperature. Petroleum coke, on the other hand, is of a porous and sponge-like nature. It is probable that it is so even in a finely divided state, so that it is easily affected by furnace gases and has a much higher rate of flame propagation.

Volatile Distilled Off at Relatively Low Temperatures

Difference in character of the volatile matter in coal and petroleum coke may also account for the fact that coke will ignite much more readily than coal of an equal percentage of volatiles. Apparently the volatile matter in petroleum coke consists largely of asphaltic compounds, which are liquids at relatively low temperatures. This material may be driven to the surface of the particles at moderate temperatures, rendering them much easier for ignition. In burning this coke in lump form on the ordinary grate, one can easily detect this oily material being driven out of the lump and bursting into flame, which indicates that the same may occur in a finely divided state.

In November, 1928, the first installation for burning pulverized coke was made under one of the boilers, using a unit pulverizer. This unit has since been in almost continual operation. This was followed by a second installation in the following May, then the third in July and a fourth in October. At the present time we have four 150-hp. boilers still equipped with stokers but the bulk of the load is now being carried by the four boilers equipped with pulverized fuel burners. The stokers are being fired with coal. Two of the boilers burning pulverized fuel have air cooled walls and the other two settings are solid walls. The solid walls show no signs of deterioration at this date.

In the hollow wall settings the exhauster fan is connected to the air space, drawing the air for combustion through this space, cooling the setting and preheating the air. Preheating the air is an advantage particularly during winter and rainy weather when the moisture in the coke may run high. The two boilers with solid walls are connected with the air space of the two previously mentioned settings so that preheated air may also be supplied to them. The sectional drawing,

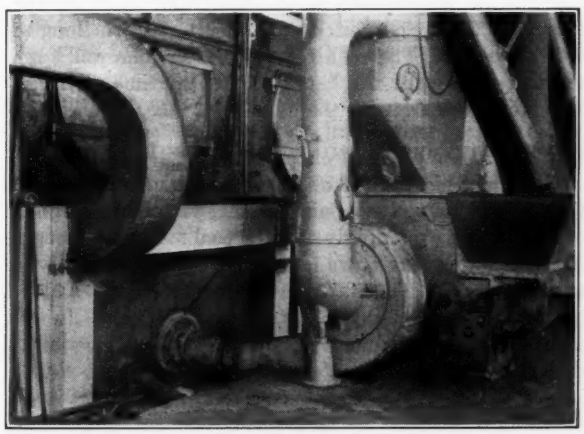


FIG. 2. ONE OF FOUR UNITS PULVERIZING PETROLEUM COKE

Fig. 1, shows the unit pulverizer arrangement with an ignition arch while the photograph, Fig. 2, shows the arrangement of the preheated air ducts.

Screen analyses of two samples taken from one of the pulverizer units are given below. Sample No. 1 shows the results with new hammers in the mill and Sample No. 2 after the hammers have been in use about 90 days and just before replacing with new hammers.

Ninety days represents from 450 to 500 t. of coke.

	Sample No. 1	Sample No. 2
Through 20 mesh, %	100.00	91.97
Through 40 mesh, %	99.92	79.66
Through 60 mesh, %	98.97	70.68
Through 80 mesh, %	92.91	61.37
Through 100 mesh, %	82.20	54.17

Maintenance cost on the pulverizer units has been small up to date, being confined almost wholly to replacement of hammers in the mills. The cost of replacing a new set of hammers including labor is approximately ten dollars, and the average life of a set is about 90 da. We are now making the hammer ourselves, 2 in. wide and ½ in. thick, from cold rolled steel. The power consumption is approximately 17 kw-hr. per ton.

Efficient Burning of Pulverized Coal

PROPER DESIGN MAKES THE NECESSITY FOR HOT REFRACTORY SURFACES TO MAINTAIN THE FLAME A THING OF THE PAST. BY H. G. LYKKEN*

WHEN PULVERIZED coal was first applied to the boiler furnace, a number of small fish-tail burners were used. The coal was introduced with a small percentage of primary air, sometimes as low as 10 per cent. The remainder of the air for combustion was introduced through numerous ports in the furnace wall, along the path of the flame. The rich mixture would seemingly ignite at the burner. Only a partial burning or gasification of the coal could take place at the burner; progressive combustion, however, was accomplished as the secondary air was added along the path of the flame.

Due to delayed combustion, the flame was necessarily long. Coal was usually fired downward to make the flame double back upon itself and to give the longest possible travel. The required furnace volume was large to insure space for the flame, as well as time to insure mixture of the air with the gas.

PROGRESSIVE COMBUSTION USED IN EARLY INSTALLATIONS

Back of this method of burning pulverized coal was the theory that a coal-air mixture would not ignite unless it was exceedingly rich in coal. It was thought impossible that a mixture having all the air required for combustion (13 lb. of air per pound of coal) could be heated up to the ignition point at the burner. It was assumed that the flame, if it did form, would blow away due to the chilling effect of the large amount of air.

For several years, most of the installations were based on this theory (which may be termed progressive burning) and some are yet being made. From the beginning, however, many engineers would not subscribe to the theory and started experimenting along diverse lines. They hoped for shorter flame, less flame volume and higher heat liberation per cubic foot of furnace than was possible with the progressive method. They felt that adding the secondary air at various points in the furnace made air proportioning difficult with the mixing subject to the accident of convection currents and, as such, not a positive and controllable factor.

Some thought that when the coal was entered with only a small percentage of the air, with the coal particles entering the hot furnace in close contact, there would be fusion of the particles in the coking stage, preceding combustion, so that, regardless of how fine the coal was pulverized, it would burn as flakes and aggregates of a large number of particles and not as pulverized coal. This also would lengthen the flame, increase the carbon loss in the flue gas and result in a high percentage of flake ash.

BURNING TAKES PLACE IN SEVERAL STAGES

Under the theory that most efficient combustion calls for introducing all air required for combustion with the coal and that the ideal condition calls for surrounding each coal particle with an atmosphere of air sufficient to burn it, the stages in the burning would be as follows:

1. Drying stage. The coal particle would heat up, due both to radiant heat absorption by the carbon and convection heating the surrounding air. The moisture would leave to mingle with the air.

2. Distillation stage. The particle would continue to heat up in the same manner and the volatiles would leave and mix with the surrounding air so that a coke skeleton would remain.

3. Ignition stage. At this point, we get more into the realm of the problematic. It may be assumed that most of the volatiles must be dissociated into simpler gases and free carbon before they will ignite. This is an endothermic reaction and the dissociation temperature, as well as the ignition temperature of the simpler gases is higher than that of the carbon.

So, considering the coke particle by itself, surrounded now by an atmosphere of a mixture of air, water-vapor and gas, it no doubt reaches the ignition temperature first by radiant heat absorption. Then when oxidation of the carbon particle begins, the temperature for ignition of the simpler gases is rapidly reached as well as the dissociation temperature of the more complex volatiles. The gas and air mixture igniting will then burn rapidly, leaving the coke particle to complete its oxidation in an intensely heated atmosphere.

But of course ignition will take place by convection in the air-gas mixture when once started at some point in the furnace, and continue to burn as a gas-air mixture as long as the gas is continuously generated from the incoming coal particles and sufficient oxygen is present. Under this consideration, with higher volatile coals, there may be entire independence of ignition from the coke particle. The ignition is propagated in the gas-air mixture in a self-regenerative flame in which more gas is continuously supplied by the distillation process. The coke particle can be assumed to burn independently in the gas flame, by direct oxidation as some would claim, but more probably by gasification first contributing its own burnable gas to the total gas volume.

RADIANT HEAT PROBABLY PLAYS THE MOST IMPORTANT PART

No doubt both radiant heat absorption by the carbon, where it becomes the kindling torch and convection in the gas-air mixture, contributes to the net results, with the radiant heat playing a greater part with low volatile fuels.

4. Oxidation. Apparently, the volatile, where present, must burn out first, even when the oxidation of the coke may start first, leaving the coke particle suspended in an atmosphere of the remaining air and product of the volatile combustion, the whole highly heated by the burning of the gas. At this temperature, any one of several things may happen to reduce the coke particle: The water vapor in contact with the incandescent carbon will produce the well-known water-gas reaction, $H_2O +$

*The Strong-Scott Mfg. Co., Minneapolis, Minn.

$C = H_2 + CO$; or the CO_2 will oxidize C to CO, and the free oxygen, if it ever does get in contact with the carbon, will react to form CO_2, which upon continued contact reacts with additional carbon to CO. The most likely reaction is reduction by the carbon of the CO_2 to CO, $C + CO_2 = 2\ CO$, which in turn unites with the free oxygen in the atmosphere about the particle, with the cycle ever repeating.

A carbon particle at this temperature surrounded by a close clinging envelope of assumed inert CO_2 is inconceivable. If any gas envelope can be conceived of, it would necessarily consist of combustible gases such as hydrogen and CO from the water-gas reaction or CO from the reaction with CO_2. Such a gas envelope of combustible gases would, of course, freely diffuse into the surrounding atmosphere and burn, if any oxygen is present.

Combustion Probably Takes Place in Two Stages

Burning of the carbon is then probably a double reaction, the first stage being a reduction to a combustible gas as follows:

$C + CO_2 = 2\ CO.$

$C + H_2O = H_2 + CO.$

The second stage is the burning of these gases with the oxygen present, and the cycle repeating.

If this analysis is correct, it can be seen how important it is that all the oxygen required to complete the combustion is present and adjacent to each fuel particle at all stages, since from the instant the temperature is high enough, the rapidity of the reaction or burning is dependent upon the continuous reaction between the oxygen and the gas generated.

It has already been indicated that the flame propagation is principally due to convection in the gas-air mixture when high volatile coals are used. It is probably due to the same factor in a large measure where little or no volatile is present, the gas in this case being generated as burned by the carbon. This indicates the equal importance of the full oxygen supply being present for the maintenance of ignition and flame propagation.

Extensive experiments have been made by the writer with the fish tail burner, entering all the air with the coal. These burners were of relatively large area so that the entrance velocity was never more than 45 ft. per sec. and often as low as 20 ft. per sec. They were used in installations ranging from 150 hp. return-tubular boilers to 750 hp. water-tube boilers designed for 200 per cent of rating. A great variety of coals was used ranging from 18 per cent volatile up, as well as petroleum coke.

In no case was any difficulty experienced in maintaining ignition, getting a clear cut flame burning up to the mouth of the burner, or in obtaining complete combustion with a minimum of excess air when the distribution of the fuel in the air was good.

Good Distribution Is a Difficult Problem

Apparently when each coal particle can be introduced into a furnace surrounded by the necessary air required to oxidize it, all the conditions for speedy and complete ignition exist and the assumed time element required to heat up the entering mixture is more than offset by the more rapid reaction due to the higher oxygen content in the mixture. The main difficulty with such burners is, however, maintaining a uniform distribution, particularly over the necessary range of ratings.

In the vortex or turbulent type of burner, which is now coming into wide use, good distribution can be maintained over a large range of ratings because much higher velocities can be maintained in the approach pipe so that adequate velocities for carrying the coal can be maintained even at low ratings.

In this type of burner, the lineal velocity in the approach pipe is translated by a stationary impeller in the burner to a vortex action. This has an advantage in that the forward progression of the coal-air mixture is arrested as it leaves the burner and expands to a mushroom type flame. This, of course, shortens the flame and utilizes to better advantage the volume at the front end of the furnace.

With this type burner, it is possible to get and maintain a good distribution of coal in the air mixture. There are a large number of such burners on the market falling into two classes. In many of them the coal and air are mixed in the proper proportion either before entering the burner or in the burner so that the issuing mixture is homogeneous.

In the second group, coal is entered with the primary air, while the secondary air in varying proportions is entered around the mixture to mix in the forward portion of the furnace. The intention is, of course, that the mixture shall take place as early as possible in the progress of the flame.

Due to the spreading of the flame and the better utilization of the forward end of the furnace, there is better utilization of the furnace volume, and saving in the size of the furnace. Better distribution, easier maintenance, distribution and wider range of ratings have already been referred to. It is possible with the turbulent type burner to supply burners with large capacities and maintain small flames in large furnaces.

Hot Furnace No Longer Necessary

Many engineers hold the theory that there is a speeding up of combustion due to a relative movement of the fuel particles in the gas effected by the turbulence, resulting in more rapid change of the atmosphere about the fuel particles, scrubbing the spent products of combustion off the fuel particles.

Whether this relative movement of solids in the gas is enough greater to have any effect and whether such scrubbing action, if it does take place, is of much consequence, is, in the writer's opinion, a debatable question.

It is fair to assume that there is localized about each particle, regardless of its movement in the atmosphere, sufficient turbulence due to temperature stresses and resultant convection currents to intermingle the oxygen and the combustible gases that, as a matter of fact, surround the particle.

With the development of the turbulent burner, the present art of burning pulverized coal has progressed to a stage where it is possible, at least with most coals, to maintain a flame and get good combustion in a relatively cold furnace and in a relatively large furnace, so that a wide range of rating can be provided for. The necessity of a hot furnace and hot refractories to maintain the flame is a thing of the past.

Electric Control for Pulverized Fuel Feed

MOTOR DRIVE SPEED REGULATED BY ARMATURE OR FIELD RHEOSTATS WITH DRUM CONTROLLERS. BY R. G. LOCKETT*

APPLICATION of powdered fuel to steam boilers is generally worked out most advantageously by the use of electric motors and control in combination with automatic combustion control.

For the bunker system of handling the fuel some form of regulating apparatus is required at the burner, which will feed the proper amount of fuel for the load and combustion conditions; hence the term feeder for device which apportions the fuel to the burner. Such device usually take the form of a screw impeller and is driven, in electrically controlled systems, by a motor whose speed can be regulated.

In many installations, close speed control of feeder motors is required and, for that reason, direct-current motors prove more satisfactory. Two general schemes are used in this work for handling shunt-wound motors, in order to keep the speeds of individual motors close to the desired value. In one, armature regulating resistance is arranged in gangs of rheostats, controlled by hand or by automatic devices and used with constant speed motors. In the other, rheostats are similarly arranged in gangs but used as shunt-field rheostats on variable speed motors. Both methods find wide acceptance.

When using armature resistance, the individual rheostats are connected also to an equalizer, so that all armatures in a group receive the same voltage. Using this method, the field strength on individual motors can readily be adjusted permanently so that the motor speeds hold together throughout the speed range.

*Electrical Engineer, Cutler-Hammer, Inc.

When using shunt-field regulation, more satisfactory results are usually secured, if the motors are selected for the service. Standard industrial motors, which may be entirely satisfactory for other purposes, may deviate too much from the desired speeds when used on high-speed ranges and running near full speed.

One common method of assembling regulating, rheostats to handle a group of feeders is shown in Fig. 1, of a regulating unit built into a board. The motors driving the feeders must be arranged to start independently and regardless of whether other motors in the group are running. A small automatic starter is often used for this service, installed in separate rooms which need not be explosion-proof or gas-tight and controlled by explosion-proof or gas-tight pilot devices located where desired.

When the fuel is pulverized at the boiler front and there is no bunker storage, the amount of coal being burned is governed by controlling the output of the pulverizer. This may be accomplished by regulating the speed of the motor which feeds coal to the pulverizer, by regulating the pulverizer speed, or both. The pulverizers, on account of the horsepower required, are usually driven by alternating-current motors, slip-ring motors being common when speed control is necessary. A type of regulator adapted for this service is shown in Fig. 3. This is a unit controller, self-contained and wired internally by the manufacturer, such units being sometimes built into switchboards with the drum regulator in the rear.

Some feeder installations require close adjustment

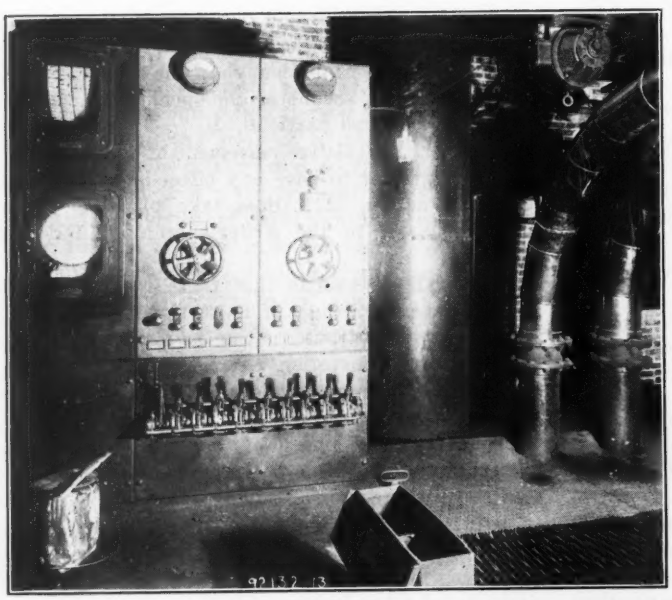


FIG. 1. C-H DIMMER BANK USED FOR FEED CONTROL AT BINGHAMTON, N. Y.

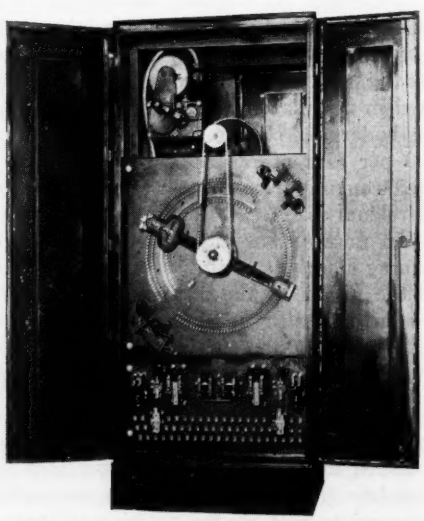


FIG. 2. GANG CONTROLLER FOR FOUR MOTORS

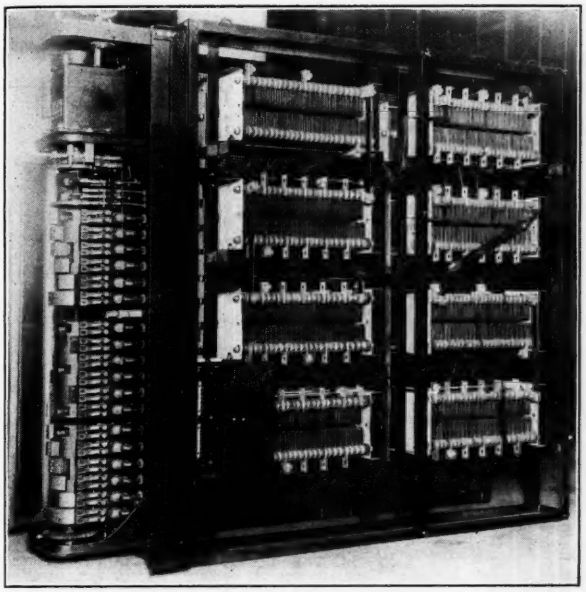


FIG. 3. RHEOSTATS AND CONTROLLER FOR SLIP RING PULVERIZER MOTORS

of individual regulators on the feeder motors. This adjustment can be made on the regulator in Fig. 1 by freeing an individual handle from the master lever, moving to the desired position and locking to the master shaft. The locking action is obtained by rotating the handle in its socket.

Figure 2 shows a motor-driven feeder regulator for four motors, part of a unit pulverizer system. Each end of the regulator arm controls a feeder motor, a duplicate regulator on the rear handling the other two. The arm ends are adjustable mechanically to compensate for slight irregularities in feeder motors. The enclosure shown is dust-tight, so that the regulator unit may be mounted in the boiler room, yet be protected from coal and ash dust.

A. S. M. E. Honors Two Japanese

OF THE MANY interesting ceremonies of the World Engineering Congress recently held in Tokyo, Japan, one was the conferring of honorary membership in American Society of Mechanical Engineers upon Viscount Eiichi Shibusawa. John R. Freeman, past-president of both the A. S. M. E. and the A. S. C. E., reviewed the influential career of Viscount Shibusawa as the reason for his inclusion with the 20 other men throughout the world who have been similarly recognized.

Dr. Elmer A. Sperry, chief American delegate to the World Engineering Congress and past-president of the A. S. M. E. (Dr. Sperry was president of the Society at the time of the presentation), presented the engraved certificate to the Viscount.

Viscount Shibusawa has aided in the industrial and economic development of the Japanese nation and has made strong efforts toward the promotion of world understanding. His interest in physical and chemical laboratories in all branches of engineering in Japan is well known.

Distinguished work of engineers was recognized when the Holley Medal was presented to Baron Chisaburo Shiba, one of the moving spirits of the recent World Engineering Congress in Tokyo. Baron Shiba has developed the highest known rapidity in the taking of scientific motion pictures, his apparatus being capable of photographing at the rate of more than 20,000 frames a second. Dr. George F. Burgess, director of the United States Bureau of Standards and advisor to the National Board of Aeronautics, stressed the world-wide importance of Baron Shiba's work. F. B. Jewett, president of the Bell Telephone Laboratories, also spoke.

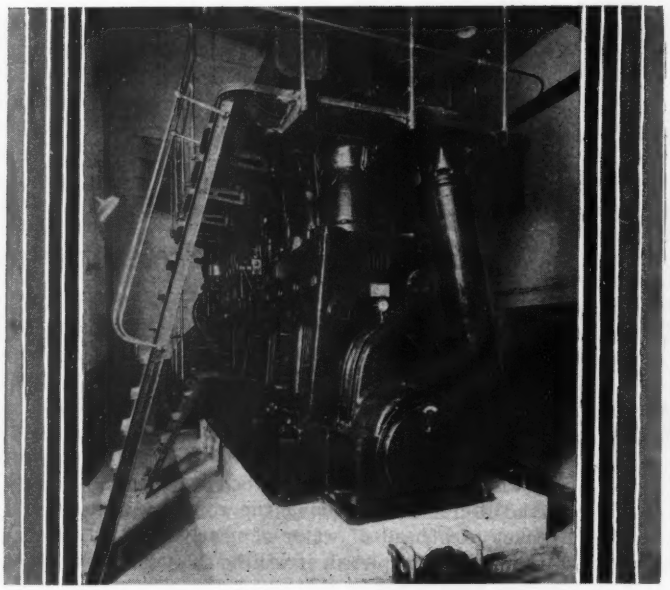
Huge Water-Power Project in the Swiss Alps

SWITZERLAND, one of the most highly electrified countries in the world, is increasing her developed water power by 360,000 hp. with the construction of an extensive hydroelectric project near the Grimsel Pass, which unites the valley of the Rhone with that of the Aare, a tributary of the Rhine. From one end of the undertaking to the other is a matter of substantially 12½ mi. At different levels along the route, advantage will be taken of a head of water of nearly 4000 ft. It is said that, when completed, it will be the largest development of its kind in the world.

As a preliminary, it has been necessary to build a funicular or inclined cog railway—the steepest on the continent—in order to get materials and supplies to the site at which the Grimsel Dam will rise to a height of 371 ft. In its ascent of 1476.5 ft. from the Handeck to the Gelmersee plateau, the funicular covers a distance of 3281 ft. It is designed to carry loads not exceeding 10 t. and, as a precautionary measure, the carriages are provided with quick-acting brakes that enable the cars to come to a stop at the end of a run of only 12 in. after application.

This is just one of the many difficulties with which construction engineers are having to contend on this job high up in the Swiss Alps. Most of them can be coped with but there is one they cannot overcome: Owing to the severe weather conditions at that altitude, progress on the work will be exceedingly slow, as it will be possible to carry on operations for but three months out of the twelve. The building period of the Grimsel Dam, for example, will have to be stretched out over four years instead of one, the estimated actual working time.

ACCORDING TO A REPORT made to the American Institute of Electrical Engineers by sixteen power engineers and electrical research experts who have been conducting field studies of effects of lightning on overhead transmission lines during the past year, lightning now presents the only serious remaining problem to the continuity of electric power service. They expressed the hope that it will soon be possible to design a lightning-proof transmission line. Of the various instruments which modern science has created to assist in the fight against the menace of lightning, the hypersensitive cathode-ray oscillograph with its swift-acting electron beam, came in for the major share of glory. It can be adjusted to show surges lasting only a few millionths of a second and will photograph the wave forms of voltages set in operation by a lightning stroke as it flashes along an overhead electric wire.



Growth of Texas Diesel Plant Continues

GOOD MANAGEMENT OF BRADY, TEXAS MUNICIPAL WATER AND LIGHT PLANT HAS RESULTED IN EFFICIENT OPERATION AND ENABLED THE MUNICIPALITY TO ADD NEW UNITS AS REQUIRED THROUGH SAVINGS EFFECTED BY THE OPERATING UNITS. OPERATING FORCE ATTENDS WATER WORKS EQUIPMENT AS WELL AS POWER AND LIGHT UNITS. FEATURES OF THIS PLANT INCLUDE REMOTE CONTROL OF ENGINE SPEED AND SAFETY DEVICES FOR AUTOMATICALLY SHUTTING DOWN THE ENGINE IF WATER OR LUBRICANT FAIL

RAPID GROWTH of Brady, situated in the heart of Texas, necessitated provision for adequate power and light. In 1912, the city purchased a privately owned steam plant for this purpose. Seven years ago, the city substituted Diesel for steam motive power, purchasing two 100-hp. Fairbanks-Morse engines. As the load increased, another 100-hp., a 300-hp. and a 360-hp. engine were purchased in turn. The most recent power unit addition consisted of a 750-hp., 22 by 30-in., 4-cylinder, 4-cycle, airless-injection De La Vergne model VB Diesel engine operating at 180 r.p.m. and direct connected to a 500-kw. General Electric generator and direct connected exciter.

Forced feed lubrication is employed. A geared pump, driven off the crankshaft, picks up the oil from the engine sump pit and forces it through the De La Vergne duplex lubricating oil filter, then through a Griscom-Russell multi-whirl lubricating oil cooler and then into a 200-gal. pressure tight overhead tank having a conically shaped bottom into which the oil may settle. From this tank, the pressure maintained by the pump forces the oil through the engine bearings, from which it drains into the sump filter pot. A pipe line from the bottom of the cone in the tank through which a portion of the oil is drawn continuously, leads to a lubricating oil heater from which it goes to a 200-g.p.h. Sharples No. 55A, centrifuge.

HEATING FACILITATES LUBRICANT RECLAMATION

Lubricant heating is done in an insulated metal tank in which is placed about 70 ft. of ½-in. copper coil, through which the oil is circulated. This is warmed in a water bath which is heated by an electric hot spot, to from 170 to 180 deg. F., which has been found to be the best temperature for centrifuging this oil. Failure of lubricating pressure, for any reason, sets in operation an automatic stop which cuts off the fuel supply to the engine thus promptly shutting it down.

Water cooling is accomplished in a closed system. The system used was enlarged for the De La Vergne unit by the addition of another soft water pump and more coils. From the engine funnels, the water flows by gravity to a hot well or sump from which it flows by gravity to horizontal centrifugal pumps which force it through 12 stands of 2-in. cooling coils, 12 pipes high. From here the water line branches, one line going to an overhead tank which floats on the line; the other leading back to the engine intake header. During the summer, water enters the cylinder jackets at about 80 deg. and is discharged at about 120 deg.

All make-up cooling water which is taken from the city mains, is treated in a zeolite water softener. Tests on the raw water used show its hardness to be 20 grains. The raw water, used for cooling the coils in which the jacket water flows is circulated first over the cooling tower, which has a capacity of 3000 gal., then over the coils to the raw water basin where two pumps recirculate it over the cooling tower. Because evaporation can occur only at the overflow funnels, the amount of make-up water required, is very small.

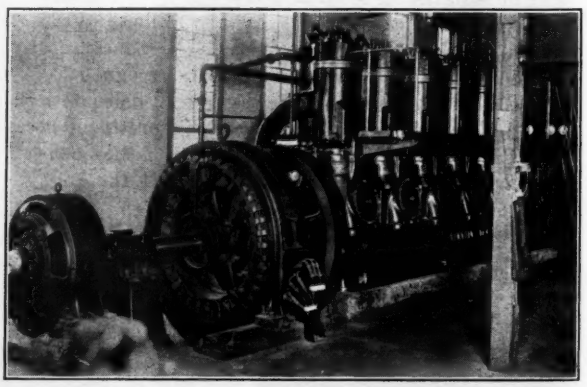


FIG. 1. 360-HP. FAIRBANKS-MORSE DIESEL ENGINE DIRECT CONNECTED TO 240-KW. GENERATOR

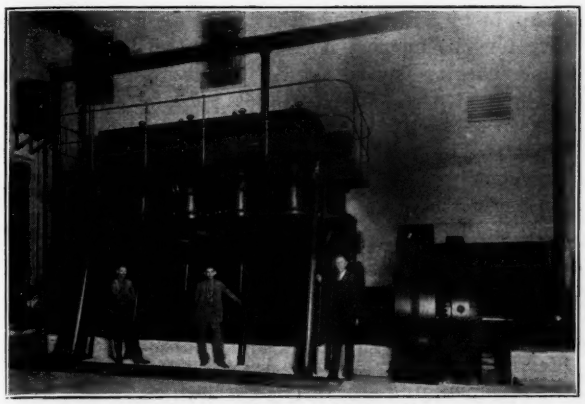


FIG. 2. 750-HP. DE LA VERGNE DIESEL ENGINE. IN THE PICTURE, FROM LEFT TO RIGHT, ARE J. R. BURKE, ENGINEER; F. S. ERICKSON, CHIEF ENGINEER AND EDWARD GUSLIN, SUPERINTENDENT OF THE BRADY WATER AND LIGHT DEPARTMENT

To prevent any possible chance of failure of continuous flow of water through the engine while it is operating, a balanced valve is connected in the engine fuel pump suction header. If the pressure on this valve drops below 4 lb., the valve closes the fuel supply, consequently it promptly shuts the engine down. The De La Vergne engine intake air comes from outside the building and is cleaned by passing through a Reed air filter.

Fuel oil is received in tank cars on a railroad siding which is at least ½ mile from the plant but there is a 30-ft. drop in elevation between the two points so that during the warmer weather the oil flows by gravity through the 3-in. pipe from the car to an underground 30,000-gal. concrete storage tank; in very cold weather, a motor-driven pump is required. The storage tank is located 10 ft. south of the engine house. The fuel oil used has a gravity of from 28 to 30. Operating on ½ load, the 750-hp. engine delivers 9 kw-hr. per gal. of fuel.

Reliability Promoted by Repeated Filtering

Fuel oil is filtered four times before it is injected into the combustion chamber. A suction strainer is used in the main fuel oil storage tanks, an overhead day storage tank provides opportunity for settling of water and other foreign substances, a De La Vergne duplex fuel oil filter is inserted between the overhead day tank and the engine proper, the fuel oil standpipe box mounted on the engine near the fuel pumps contains the third filter and the fourth is a filter screen which is a part of each injection nozzle.

Exhaust temperatures are indicated by a Brown pyrometer which is installed on the engine. In normal operation under full load, the exhaust temperature is approximately 600 deg. F. The exhaust pipe of the De La Vergne engine is water cooled by means of a jacket which extends from the manifold to the floor line.

Attractive engine room appearance has been secured by placing all piping in trenches just below the floor line. The piping is painted in conventional colors for distinguishing the various fluid lines. The concrete base of the engine foundation is painted in white enamel

Motive Power Data

Unit No. 1

Fairbanks, Morse & Co. 100-hp. Diesel Engine

Direct connected to an alternating-current generator, Fairbanks-Morse & Co. D type, 75 kv-a., 257 r.p.m., 3-phase, 60-cycle, 2400 v., 18 amp. per term. 75 kv-a. continuous duty 1 p.f. 40 deg. C. rise.

Direct current Fairbanks, Morse & Co. exciter. Shunt wound type C.P. frame 7. 60 amp., 1400 r.p.m., 125 v., 7½ kw. continuous 40 deg. C., 125 per cent overload 2 hr. 55 deg. C.

Unit No. 2

Fairbanks, Morse & Co., 300-hp. Diesel Engine

Direct connected to an alternating-current generator, Fairbanks, Morse & Co. Type D, 250 kv-a., 257 r.p.m., 3-phase, 60-cycle, 2300 v., 200 kw., 0.80 p.f., 62.8 amp. per term., 250 kv-a. continuous duty at 1 p.f., 40 deg. rise.

Direct-current Fairbanks, Morse & Co, exciter. Type TRC, Frame 26, 100 amp., 257 r.p.m., 125 v., 12.5 kw., continuous 40 deg. C. rise, 125 per cent load 2 hr. 55 deg. C.

Unit No. 3

Fairbanks, Morse & Co. 360-hp. Diesel Engine

Directed connected to alternating-current generator, Fairbanks-Morse Mfg., Type D, 300 kv-a., 257 r.p.m., 3-phase, 60-cycle, 2400 v., 72.2 amp. per term., 300 kv-a. continuous duty 1 p.f., 40 deg. C. rise, 240 kw.

Direct-current Fairbanks, Morse & Co., exciter. Type MX, Form MX 20, 120 amp., 257 r.p.m. full load, 125 v., 15 kw. continuous duty 40 deg. C., 125 per cent load 2 hr. 55 deg. C.

Unit No. 4

I. P. Morris-De La Vergne, Inc. Diesel Engine

Direct connected to alternating-current generator, General Electric Co. Type ATI 625—180, Form E.J., 2300 v., 180 r.p.m., 157 amp. per term., 60-cycle, 0.8 p.f., 3-phase, 500 kw., 625 kw-a., 0.8 p.f. continuous 50 deg. rise.

Direct-current General Electric Co, exciter. Compound wound, Type M.P.L., 112 amp., 180 r.p.m., 125 v., 14 kw. continuous 50 deg. C.

Water works equipment including air compressor for air lift and centrifugal pumps for feeding the city mains, is located in another room of the plant.

Typical Daily Plant Log

Run No. 1 from 8 a. m. to 4 p. m.	
Number of kilowatt-hours generated	70,200
Number of gallons of fuel used	7,043
Number of quarts of lubricant used	111
Number of kilowatt-hours per gal. of fuel used	9.96
Number of kilowatt-hours per qt. of lubricant used	632
Run No. 2 from 4 p. m. to 12 night	
Number of kilowatt-hours generated	66,050
Number of gallons of fuel used	6,650
Number of quarts of lubricant used	117
Number of kilowatt-hours per gal. of fuel used	9.93
Numbers of kilowatt-hours per qt. of lubricant	564
Run No. 3 from 12 night to 8 a. m.	
Number of kilowatt-hours generated	46,700
Number of gal. of fuel used	5,197
Number of quarts of lubricant used	61
Number of kilowatt-hours per gal. of fuel used	8.96
Number of kilowatt-hours per qt. of lubricant	916
Labor engineering cost per kilowatt-hour	.00329
Fuel cost per kilowatt-hour	.00331
Lubrication cost per kilowatt	.00018
	.00678
Fuel cost $1.35 per barrel	
Labor cost $605.00	
Total number of kilowatt-hours generated	182,950
Total lubricating oil, qt	289
Fuel oil, gal	18,890
Kilowatt-hours per qt. of lubricating oil	633
Kilowatt-hours per gal. of fuel	9.68

Costs of Operation for the Year

Cash on hand	$ 6,153.89	
Water collections	24,925.97	
Light collections	54,471.38	
Sewer collections	2,444.70	
Total		$37,995.94
Disbursements		
Operating Expense:		
Engineers' salaries	$5,986.75	
Office salaries	5,016.00	
Fuel	6,499.77	
Lub. oil, waste, etc	2,733.01	
Car and truck expense	1,045.97	
Insurance	1,090.20	
Replacement water	769.89	
Replacement light plant	1,127.02	
Charity	90.00	
Legal	150.00	
Office rent	15.00	
Office supplies	247.76	
Interest, water works bond No. 3	5,400.00	
Total		$30,171.37
		$57,824.57
Capital Expenditures:		
Plant improvement	$26,268.21	
Water works bond No. 3 extension mains	3,000.00	
Water works improvement fund	3,600.00	
Sewer extensions	1,044.55	
Extra labor, on extensions and improvements	7,999.50	
Office fixtures	848.00	
Merchandise	66.99	
Extension transportation lines	6,017.07	
Extension water mains	6,929.78	
Total		$55,774.10
Balance		$ 2,050.00

and, as the engine itself is painted black, a pleasing effect is presented in combination with the white ceiling and walls and dark wall border. A 2-t. crane spans the room.

Remote Control

Switchboard installation for the De La Vergne engine is in an adjacent room where the older engine units are located. The new engine is controlled by a motor governor which is attached to it. The speed is controlled by push buttons mounted on the switchboard thus permitting of convenient paralleling and adjustment of load between the new and older units.

The daily electrical load varies from 3000 to 6500 kw-hr. The output in December was 144,300 kw-hr. The peak load is 625 kw. and the average load for the entire plant is 250 kw. The original two 100-hp. units were removed and sold. The plant now consists of a total of 1510 hp. as described.

Supercharging of Diesels in Marine Field

By Carl Commentz

DURING THE LAST YEAR, notable developments in the application of supercharging to marine Diesel engines have taken place. By this new system, it is possible to increase the output of four-stroke cycle marine oil engines by about 40-50 per cent with but a slight increase of weight and at relatively small cost. By supercharging, the weight of combustion air in the cylinders is considerably increased so that it is possible to burn a correspondingly larger amount of fuel at each power stroke. The maximum pressure and temperature in the cylinder is not increased, so that the design of the engine itself is not altered by the innovation and no parts need any strengthening.

In the first system of pressure charging, developed by the Deutsche Werft of Hamburg some years ago, the necessary air pressure was supplied by an electrically driven turbo blower. Newer systems, developed by Buechi and Rateau, which are being applied of late on a large scale, use the power of the exhaust gases of the Diesel engine for driving turbines connected with turbo blowers. This has been found to be very advantageous, because no extra power is required for the blower. A fourth system which has been turned out by the Dutch Werkspoor Co. uses the undersides of the Diesel engine pistons for compressing the combustion air. This involves no special blower, simply enclosing the underside of the cylinders by a low pressure stuffing-box and providing governor and piping is all that is necessary with this system.

Power Increased About 50 Per Cent

The Buechi System has been first applied to the German motor-vessels "Hansestadt Danzig" and "Preussen," which ply in the passenger trade between Stettin, Danzig and Koenigaberg. The two four-cycle MAN engines of each of these vessels have together a normal rating of 3400 br-hp. without supercharging. If the blower is used, their output is increased to 6200 br-hp. or by about 80 per cent. The air pressure necessary for this purpose is from 10 to 11.5 lb. per sq. in. Supercharging is used only if it is necessary to increase the normal speed from 15 knots to 17 or 18 in order to keep to the fixed sailing schedule. In newer vessels, which are intended to run always with supercharging, the capacity of the blowers is generally designed so that the engine power is increased by about 40 or 50 per cent. In the case in the Italian Ms. Caralis with Tosi engines normally rated at 3000 br-hp. at 120 r.p.m., the Buechi supercharger increased this to 4200 br-hp. at 135 revolutions and the speed of the ship is augmented from 14.5 to 15.6 knots. In the Italian tanker Ms. Stelvio, the power of the MAN engines is increased by the supercharging arrangement from 1080 to 1380 br-hp. The British tanker Ms. Itape has two sets of Beardmore-Tosi engines developing normally 1650 br-hp. each but this is raised to 2200 br-hp. with superchargers.

Supercharging has also been applied with advantage to vessels which have been in service for some time. Thus the British freighter Ms. Lochmonar built in 1924 was fitted out with Buechi superchargers some months ago and the engine power increased from 5800 to 7250 br-hp. At the trial trip, an output of 7700 br-hp. was developed.

Success of these plants has induced of late many owners to provide blowers for new vessels. Six large motorships of the Blue Funnel Line; four vessels of the Silver Line; two passenger vessels of the Union Castle Line as well as a number of smaller and medium ships are now or soon will be under construction with superchargers.

Fuel Consumption May Be Improved

Application of superchargers does not increase the fuel consumption per brake horsepower hour and within certain limits a decrease of the specific consumption is even attained. This is due to the fact that the mechanical efficiency of Diesel engines improves with the output so that the combustion of supercharged drive is better because the burnt gases are fully expelled. There have been stated at some engines improvements of specific fuel combustion of 4.6 per cent.

The importance of supercharging lies in the fact that the weight and price of a supercharged engine, reckoned per horsepower, is decidedly smaller than that of normal engine. According to statements made by Buechi, the weight of supercharged four-cycle engines is even much lower than that of two-cycle engines, so that supercharging gives a marked advantage to four-cycle engines, as supercharging cannot be applied in the same way to two-cycle engines. Supercharging will also allow an increase in the piston speed. There is no difficulty in supercharging double acting four-cycle engines, though this has not yet been done, although solid injection engines have already been so equipped.

Anthracite, mined in eastern Pennsylvania and small areas in the West, weighs from 50 to 58 lb. per cu. ft. It is a clean, hard coal high in fixed carbon, low in volatile, noncaking, contains little tar or smoke forming substances and stores well. Because of the low volatile, it is hard to ignite but burns freely when well started.

Power from Process and Space Heating Steam

CALCULATION OF COSTS OF PRODUCING POWER BY USING TURBINE EXHAUST FOR PROCESS, SHOWN BY AN ACTUAL EXAMPLE. BY L. A. HARDING*

WHEREVER STEAM is employed for process work, the boiler pressure is determined by that part of the process requiring the highest temperature and generally the bulk of the steam is employed at a considerably lower temperature and corresponding pressure. The heat available per pound of available process steam or heat drop, for the generation of power, is the difference between the heat content h_1 of the steam at the generating pressure (initial condition) and the heat content h_2 of the steam corresponding to the pressure at which it is employed in the process (final condition), assuming adiabatic expansion (Rankine cycle). This difference multiplied by the pounds of steam so employed per hour gives the total heat available for power generation by means of reciprocating engines or steam turbines.

The more or less fixed amount of process steam available at the existing process pressure is more often found to be inadequate to supply all of the power requirements and some means should be adopted to secure as near a balance between the heat available and the heat equivalent of the power requirement as it is possible or practical to obtain with a minimum amount of expense for extra fuel. The heat available ($h_1 - h_2$) per pound of steam may be increased by (1) increasing the initial pressure (2) superheating and (3) decreasing the process pressure (back pressure).

The comparative effect on the basis of per cent gain in the heat available per pound of steam of the foregoing items based on an existing condition of 150 lb. per sq. in. absolute (135 lb. gage) boiler pressure as required for a small part of the process dry saturated steam and 55 lb. per square inch absolute (40 lb. gage) pressure for the bulk of the process steam assumed available for the generation of power, is shown by Fig. 1. The per cent gain is evidently the difference betwen the available heat per pound of steam for the existing condition and the proposed condition divided by the available heat per pound for the existing operating condition.

USE OF STEAM AND POWER LOAD CURVES

In Fig. 3 is illustrated a method employed in plotting an equivalent electric power load curve from an available process steam load curve or an equivalent steam load curve from a power load curve. It is, of course, desirable to have the actual guaranteed water rates from the several manufacturers whose machines are being considered, covering the proposed conditions of operation. These water rates will ordinarily be found to vary somewhat between the different types of machines proposed. It is believed, however, that correct use of the data herein presented will give sufficiently accurate water rates for the purpose intended. The process steam load curve and the purchased electric power load curve shown were plotted from meter readings recorded June 4 and 5, 1929, at the plant under consideration. The load curves for this date were chosen as representing a typical summer day operation when the electric power load gave a high average and maximum peak. The average steam load in this plant does not vary much from day to day during the summer months.

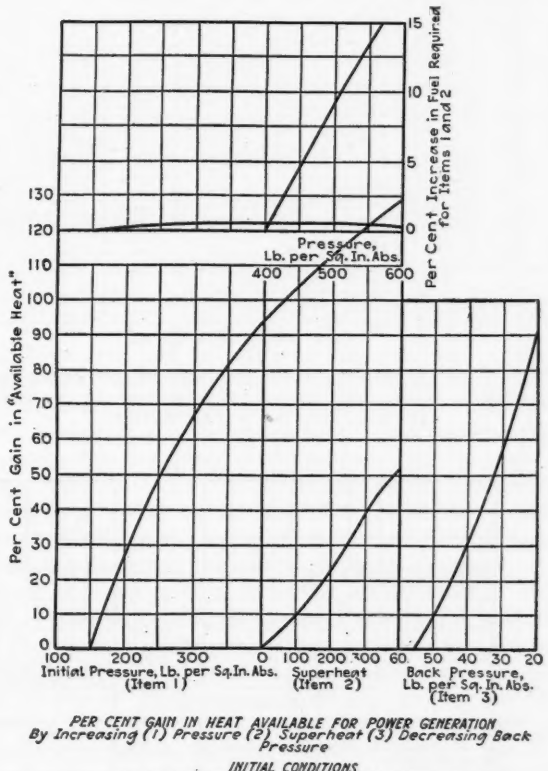

Per Cent Gain in "Available Heat"
Per Cent Increase in Fuel Required for Items 1 and 2
Pressure, Lb. per Sq. In. Abs.
Initial Pressure, Lb. per Sq. In. Abs. (Item 1)
Superheat (Item 2)
Back Pressure, Lb. per Sq. In. Abs. (Item 3)
PER CENT GAIN IN HEAT AVAILABLE FOR POWER GENERATION
By Increasing (1) Pressure (2) Superheat (3) Decreasing Back Pressure
INITIAL CONDITIONS
150 Lb. Abs. 135 Lb. Gage Dry Saturated Steam
55 Lb. Abs. 40 Lb. Gage Back Pressure

FIG. 1. PER CENT GAIN IN HEAT AVAILABLE FOR POWER GENERATION

STEAM LOAD CURVE

If it is possible to generate the electric power required by the plant from the process steam plus an amount of steam which is less than the difference between the average winter and summer steam loads, during the summer months, at a fair saving over the cost of purchased power, it would appear that the extra steam available during the heating season, as required for space heating, will further reduce the cost and show a greater yearly saving.

The steam load curve of this plant for January 14 and 15, 1929, is shown by the dashed line at the top of chart, Fig. 6. The boiler equipment at this plant con-

*President, L. A. Harding Construction Co., Buffalo, N. Y. From a paper presented before the A. S. H. & V. E. annual meeting, Philadelphia, January, 1930.

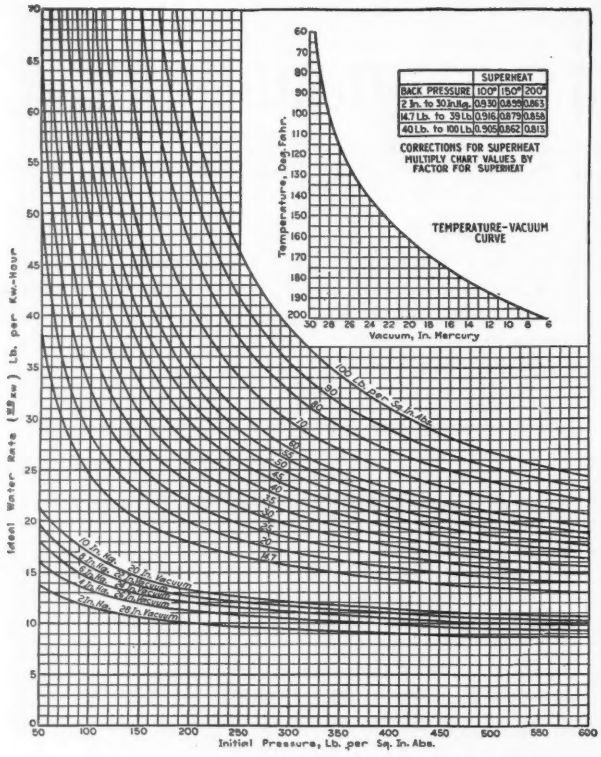


FIG. 2. IDEAL WATER RATE PER KILOWATT-HOUR FOR TURBINES WITH DRY SATURATED STEAM AT VARIOUS INITIAL AND BACK PRESSURES

sists of one 450- and four 308-hp. boilers (nominal rating). All boilers are equipped with stokers and forced draft, the stoker equipment being capable of operating the boilers at 200 per cent of rating. The boilers are designed for a pressure of 175 lb. per sq. in. gage and are not equipped with superheaters. High-pressure steam for certain operations is required at the average rate of approximately 9000 lb. per hr. and this demand is fairly constant. The remainder of the steam generated, or 49,000 lb. per hour average, it is assumed, will satisfactorily supply the remainder of the requirements (cookers, evaporators, drying, water heating) with a back pressure at the turbines of 20 lb. per sq. in. gage.

Finding Total Steam Required

To supply dry steam at the exhaust outlet of the turbines it is proposed to install superheaters for all of the existing boilers. The cost of 13,000-B.t.u. coal in the bunkers is $3.75 per ton. The average boiler and grate efficiency of this plant is 68 per cent. From an inspection of the electric power load curve it is evident that the full-load turbine rating required should be approximately 1500 kw. to provide for the peak load. Probably the most practical combination, all things considered, would be the installation of three 750-kw. machines, one of which would be a spare unit.

Assuming an initial throttle pressure at the turbine of 160 lb. per sq. in. gage (175 lb. absolute), 150 deg. superheat and 15 lb. drop through throttle with 20 lb. per sq. in. gage (35 lb. absolute) back pressure, the

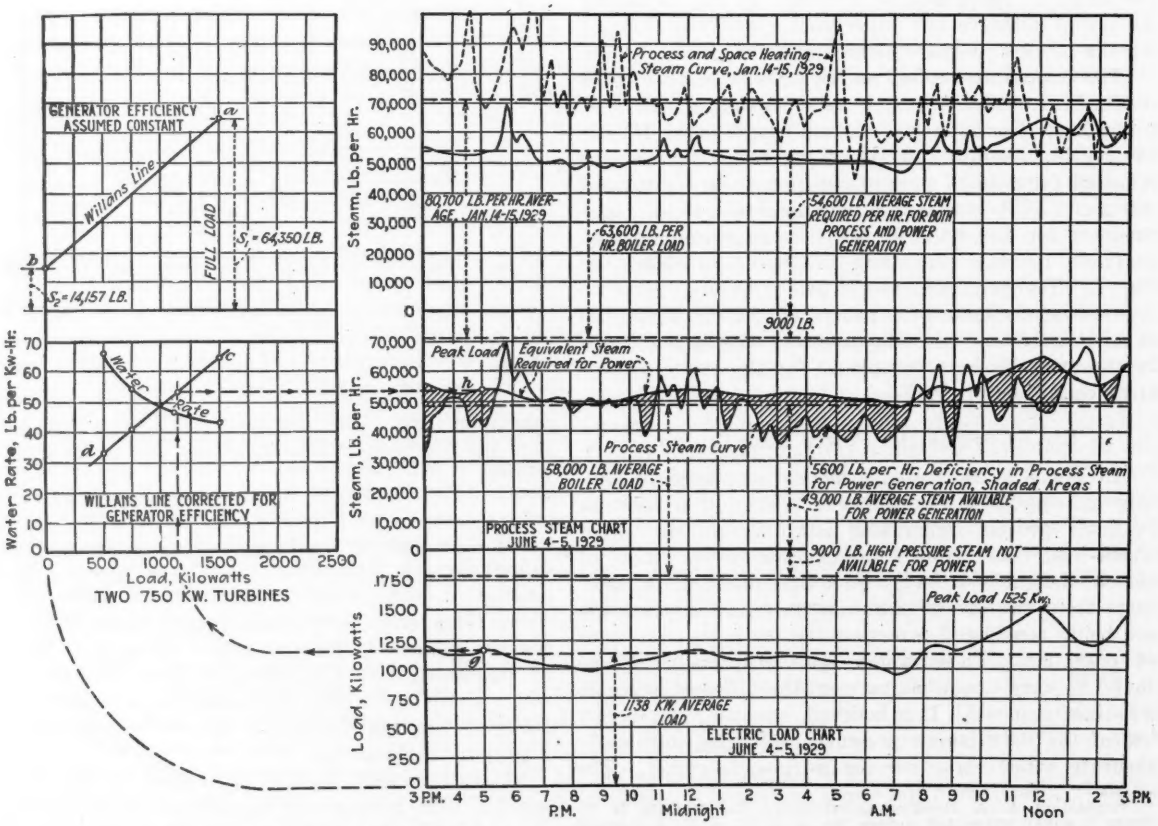

GENERATOR EFFICIENCY ASSUMED CONSTANT
Willans Line
FULL LOAD
S1 = 64,350 LB.
S2 = 14,157 LB.
Water Rate
WILLANS LINE CORRECTED FOR GENERATOR EFFICIENCY
Water Rate, Lb. per Kw-Hr.
Load, Kilowatts
TWO 750 KW. TURBINES
Process and Space Heating Steam Curve, Jan. 14-15, 1929
80,700 LB. PER HR. AVERAGE, JAN. 14-15, 1929
63,600 LB. PER HR. BOILER LOAD
54,600 LB. AVERAGE STEAM REQUIRED PER HR. FOR BOTH PROCESS AND POWER GENERATION
9000 LB.
Peak Load
Equivalent Steam Required for Power
Process Steam Curve
58,000 LB. AVERAGE BOILER LOAD
5600 Lb. per Hr. Deficiency in Process Steam for Power Generation, Shaded Areas
49,000 LB. AVERAGE STEAM AVAILABLE FOR POWER GENERATION
3000 LB. HIGH PRESSURE STEAM NOT AVAILABLE FOR POWER
PROCESS STEAM CHART JUNE 4-5, 1929
Steam, Lb. per Hr.
Peak Load 1525 Kw.
1138 KW. AVERAGE LOAD
ELECTRIC LOAD CHART JUNE 4-5, 1929
3 P.M. 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 P.M.
P.M. Midnight A.M. Noon

FIG. 3. STEAM AND ELECTRIC LOAD CURVES, SHOWING USE OF WILLANS LINE

TABLE I. HEAT AVAILABLE AND IDEAL WATER RATE IN POUNDS PER KILOWATT-HOUR FOR 150 DEG. SUPERHEAT. OTHER TABLES ARE GIVEN FOR 100 AND 200 DEG. SUPERHEAT

Back Pressure Lb. Sq. In. Absolute p_2	Initial Pressure Lb. Sq. In. Absolute (p_1)													
	100		150		200		250		300		400		600	
	B.t.u.	W. R.	B. t. u.	W. R.	B. t. u.	W. R.	B. t. u.	W. R.	B. t. u.	W. R.	B. t. u.	W. R.	B. t. u.	W. R.
28-in. Vac.	321.0	10.62	349.0	9.78	370.1	9.21	386.0	8.85	398	8.58	417.4	8.18	444	7.7
26-in. Vac.	288.4	12.05	312.5	10.9	334.1	10.2	350.0	9.75	363	9.4	382.4	8.93	410	8.33
24-in. Vac.	260.1	13.1	289.5	11.78	311.6	10.95	328.0	10.4	341	10.0	360.9	9.45	389	8.78
22-in. Vac.	243.4	14.02	273.1	12.5	295.6	11.55	312.0	10.94	325	10.5	345.4	9.9	374	9.14
20-in. Vac.	230.0	14.8	260.2	13.1	282.6	12.06	299.0	11.4	313	10.9	332.9	10.25	362	9.44
14.7	157.4	21.7	189.2	18.02	213.1	16.0	230.5	14.8	245	13.92	266.4	12.81	298	11.47
20	136.0	25.1	168.5	20.22	192.6	17.7	210.0	16.25	225	15.15	247.4	13.8	278	12.3
25	119.4	28.6	152.0	22.42	176.6	19.3	194.0	17.6	209	16.32	231.4	14.75	263	13.0
30	105.6	32.3	138.5	24.62	163.1	20.9	181.0	18.85	196	17.4	218.4	15.61	251	13.6
35	93.4	36.6	126.5	26.95	151.6	22.5	170.0	20.05	185	18.45	207.9	16.43	241	14.18
40	83.0	41.1	117.0	29.1	141.6	24.1	160.0	21.3	175	19.5	198.4	17.2	231	14.8
45	73.4	46.5	107.5	31.7	132.6	25.7	151.0	22.6	166	20.55	189.4	18.04	223	15.3
50	65.4	52.2	99.5	34.3	124.6	27.2	143.0	23.9	159	21.45	182.4	18.8	215	15.9
55	57.0	59.9	91.5	37.3	117.6	29.0	136.0	25.1	153	22.3	174.4	19.58	208	16.41
60	.....	... .	84.5	40.4	110.6	30.9	129 5	26.4	145	23.5	168.4	20 3	202	16.9
70	.....	.....	71.5	47.7	98.1	34.8	117.0	29.2	133	25.7	156.4	21 8	191	17.9
80	....	.....	60.0	56.9	86.6	39.4	106.0	32.2	122	28.0	145.9	23.4	180	18.97
90	.....	.....	49.5	69.0	77.1	44.3	97 0	35.2	113	30.2	136.9	24.95	171	20.0
100	.....	.....	39.5	86.4	67.6	50.5	88.0	38.8	105	32.5	128.9	26.5	163	20.95

ideal water rate from Fig. 2 with 160 lb. absolute pressure is:

$$WR_{kw} = 29.2 \times 0.879 \text{ (superheat correction)} = 25.5 \text{ lb. per kw-hr.}$$

Assuming an efficiency ratio for the turbine of 0.63 and a generator efficiency of 0.944, the expected full load water rate for a 750-kw. turbine-generator set for the asumed condition is:

$$EWR_{kw} = 25.5 \div (0.63 \times 0.944) = 42.9 \text{ per kw-hr.}$$

A guaranteed water rate approximately 10 per cent lower than this figure can be obtained from some manufacturers.

Total estimated steam required at full load for two 750-kw. units is:

$$2 \times 750 \times 42.9 = 64{,}350 \text{ lb. per hr.}$$

Correcting Willans Line for Generator Efficiency

It is assumed that the ratio of no load to full load steam is $y = 0.22$, the estimated steam at no load being equal to $0.22 \times 64{,}350$ or 14,157 lb. per hr. The Willans line a-b, Fig. 3, may now be constructed as previously indicated; this is evidently based on the assumption that the generator efficiency remains constant for all loads. The corrected total steam per hour, line c-d, is shown in the diagram directly below the Willans line and was plotted from the calculated data given in Table II.

The corrected total steam per hour for the various loads shown was obtained by multiplying the values as determined from the Willans line by the ratio of the generator efficiency at full load to the generator efficiency at the fractional load.

Any point, as g on the electric power load, may be translated into equivalent steam load by simply projecting over to the intersection with the total steam per hour line and transferring the equivalent power load to the steam chart, as indicated at h. Any point on the available steam chart curve may be translated into equivalent electric power by simply reversing this process. The deficiency in the process steam at various times during the day for generating the electric power required is shown by the shaded areas on the process steam chart. Integrating these areas, the average deficiency in process steam to generate the power required is found to be 5600 lb. per hr.

Average process steam available is 49,000 lb. per hr. as determined by integrating the area under the process steam load curve. The average steam generated by the boilers for all purposes is 58,000 lb. per hr. and the average required, if all power were to be generated at the plant, would be $58{,}000 + 5600 = 63{,}600$ lb. per hr. The hourly quantities of steam, as they would be required if all the power was to be generated, are shown by the steam load curve chart at the top of Fig. 3. This chart shows that the peak load on the boiler plant would remain at 78,000 lb. per hr. and is in no way affected by the problem of power generation.

TABLE II. CORRECTIONS FOR GENERATOR EFFICIENCY TO BE APPLIED TO WATER RATES IN CORRECTING WILLANS LINE

Load K.W.	Fractional Load x	Generator Effy. $\varnothing_x$	Ratio—Gen. Eff. Full Load / Gen. Eff. Frac. Load	Steam per Hr. from Willans Line—Lb. s	Corrected Total Steam per Hr. Lb.	Water Rate K.W. Hr. Lb. E W R_{kw}
1500	1.00	0.944	1.000	64350(S_1)	64350	42.9
1125	0.75	0.931	1.014	51800	52525	46.4
750	0.50	0.909	1.038	39500	41001	54.6
500	0.33⅓	0.890	1.060	31500	33390	66.8

Factor of evaporation for 160 lb. gage dry saturated steam and 200 deg. feedwater is 1.0592 and for the same pressure condition with 150 deg. initial superheat is 1.148.

The extra fuel required per hour, if all the power is to be generated is therefore:

$$\{[(63{,}600 \times 1.148) - (58{,}000 \times 1.059)] \times 971.7\} \div (0.68 \times 13{,}000) = 1274 \text{ lb.}$$

or

$$(1274 \times 24) \div 2000 = 15.28 \text{ t. per day.}$$

The exhaust from the turbine will have a superheat of approximately 59 deg. as determined by plotting its expansion line on the Mollier diagram. Dry steam will therefore be supplied by the turbines to the process.

The deficiency in process steam could be practically eliminated if the average water rate of the turbines employed could be reduced to 49,000 ÷ 1138 or 43.1 lb. per kw-hr. The estimated average rate for the assumed conditions is approximately 49 lb. per kw-hr., which would require a reduction in the full load water rate of approximately 6 lb. This would require an ideal water rate of 20.9 lb., which corresponds to an initial pressure of 250 lb. absolute or 235 lb. gage. This increase in pressure would require a new boiler installation, which is not possible in this plant.

The estimated cost of the additional equipment required, if all the power is to be generated at the plant, is as follows:

3 750-kw. steam turbine generating sets	$51,000
3 Foundations for above machines	1,500
Superheater	8,500
Piping and electric wiring	17,000
Turbine house	12,000
Total	$90,000

Cost of Making Power

Daily cost of producing electric power based on the preceding data is estimated as follows:

Fixed charges (15% of $90,000 ÷ 365)	$37.01
Additional fuel required, 15.28 t. at $3.75	57.30
Additional labor (stationary engineers)	15.00
Additional supplies	4.00
	$113.31

The average electric power load for the day was 1138 kilowatts. The estimated cost per kilowatt-hour to produce this amount of power is:

$$113.31 \div (24 \times 1138) = \$0.00415$$

Cost of purchased power at this plant averages $0.007 per kilowatt-hour. This company would apparently save at least 40 per cent of the present power bill or approximately $22,000 per year, if it generated its own power. This saving represents a return of nearly 25 per cent on the estimated investment involved.

Amount of extra fuel, as previously estimated, may be reduced by the employment of extraction or bleeder type turbines, as later more fully described, by passing the extra steam as required to generate the deficiency in power due to the lack of sufficient process steam through more turbine pressure stages to a final lower back pressure.

It is evident that the extra steam required must be wasted so that any reduction in the amount results in a direct saving in fuel.

It is considerably more tedious to plot the equivalent steam chart when a bleeder turbine is under consideration, to determine the deficiency in process steam. This is because an extraction line, as later shown, is required corresponding to each amount of steam it is desired to transfer into electric power or vice versa.

The paper then discusses the plotting of the Willans Line for bleeder turbines and calculates the power and steam balance of two cases in which exhaust or bled steam are used for heating water. Abstract of this part of the paper will be given in a subsequent issue.

Civil Service Calls for Engineers

United States Civil Service Commission announces open competitive examinations for: Associate Engineer, $3200 to $3700 a yr.; Assistant Engineer, $2600 to $3100 a yr. Applications for these must be on file with the commission at Washington, D. C., not later than March 12. The examinations are to fill vacancies occurring in the Federal classified service throughout the United States. Eligibles are especially desired for the Supervising Architect's Office, Treasury Department. Also, there is a vacancy at Edgewood Arsenal, Maryland, in a position of assistant mechanical engineer qualified as specification writer.

Optional branches are (1) aeronautical, (2) agricultural, (3) architectural (estimator and computer), (4) architectural (specification writer), (5) chemical, (6) civil (general), (7) electrical, (8) heating and ventilating, (9) highway, (10) mechanical, (11) radio, (12) structural steel and concrete bridges, (13) structural steel and concrete buildings, (14) any other specialized branch of engineering work. Duties will be in connection with original research or investigation, or design and construction. Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience.

Full information may be obtained from the United States Civil Service Commission, Washington, D. C., or the Secretary of the United States Civil Service Board of Examiners at the post office or customhouse in any city.

On the recommendation of the Petroleum Division, the A. S. M. E. Main Research Committee has authorized the organization of a Special Research Committee to study problems connected with automatic pipe-line pumping stations in the oil fields. The purpose of this project is to confer on various methods of installing equipment in automatic pipe-line pumping stations and to conduct experimental work and testing to determine which of the installations are the most efficient and reliable.

Mechanical methods now generally in use for separating lubricating oil from steam-condenser water have been improved upon, so it is claimed, by a German scientist. In the new method, which is known as the Hoyer process, a direct current is passed through the condenser water. This breaks up the milky emulsion into small foamlike flakes and makes filtration possible. About 1 kw-hr. is consumed for every 175 cu. ft. of water thus purified.

Self-Contained British Turbine Sets Widen Industrial Field

By F. Johnstone-Taylor

SMALL STEAM TURBINES for industrial plant service have increased rapidly in importance because of their compact design and adaptability to electric power generation. One of the disadvantages of this equipment for condensing service has been the more or less troublesome job of arranging the condenser, air pumps, extraction pump, circulating pump and other minor auxiliaries which call for a good deal of basement space. This fact has now been appreciated by some of the steam turbine builders who have recently introduced self contained units in powers suited to industrial conditions in what may be regarded as quite small units.

This class of turbine, of which a typical example is shown in Fig. 1, is quite simple. Figure 2 shows the general lay-out of a unit by the Metropolitan-Vickers Co. It involves a single cylinder turbine with one velocity stage and eight impulse stages ranging in output from 300 to 4000 kw. and having an average speed of 5000 r.p.m. It will be observed that the turbine is mounted on top of a boat shaped condenser which also supports the necessary control gears. Next to the turbine cylinder is a 5 to 1 single reduction helical gear. Then come the generator, exciter and circulating pump, the latter connected through a flexible coupling. The extraction pump at the base of the condenser is of the vertical centrifugal type with a single eye bronze impeller mounted on a steel shaft, while the air pump is of the two-stage steam ejector class with intercondenser and aftercooler.

Compact Design for 300-Kw. D.C. Set

Another such unit made by W. H. Allen Sons & Co., is shown in Fig. 3. This is a 300-kw. set driving a direct current generator through gearing. The turbine cylinder is supported by the somewhat flat condenser while the cylindrical portion to the right of the gear box in the center of the set is an oil cooler. Behind the gear case are located the air pump, which is of the two-stage steam jet class, and its intercondenser. The governor and other control gear are clearly visible at the front

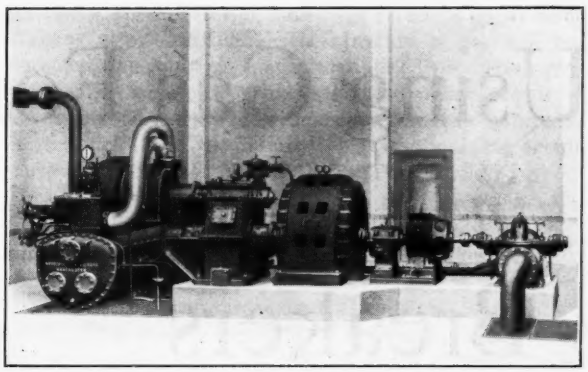


FIG. 2. THIS TYPE OF UNIT IS BUILT IN SIZES OF FROM 300 TO 4000 KW.

beside the high-pressure portion of the turbine casing. Beyond the outboard bearing on the extreme right of the generator is the circulating pump, while a gear on the low-pressure end bearing drives the spindle of the vertical extraction pump which is just visible in the pit.

The turbine itself is an impulse machine with a single velocity compounded stage and six velocity stages and is designed for a speed of 6000 r.p.m. with steam at 170 lb., 150 deg. F. superheat and 28 in. vacuum. In order to allow for expansion, the high-pressure end of the turbine is constructed so that it is free to move axially in special guides, though the low-pressure end is fixed rigidly to the condenser which supports it.

Auxiliaries Are Direct-Driven

Sets of this kind can be regarded as an attractive proposition. All the auxiliaries are direct driven which eliminates auxiliary motors and control gear. Prior to the introduction of this arrangement, a steam turbine plant of similar capacity would have required power house construction with a basement and equipment on two floors. In these new designs, the units are of remarkably small dimensions and are so combined and arranged that they need no basement or even foundations as ordinarily understood. All the mounting required is a simple reënforced concrete floor with a small pit about 2 ft. 6 in. deep for the condenser and the oil tank. The total foundation cost for a set of 1000 kw. is only about one-sixth of what it would otherwise be.

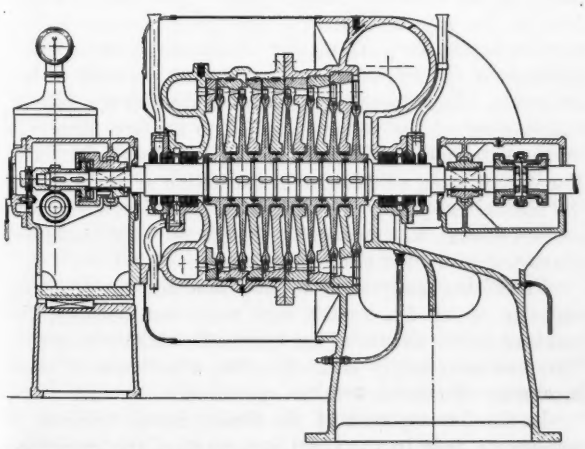


FIG. 1. CROSS SECTION OF A TYPICAL TURBINE OF THE CLASS REFERRED TO

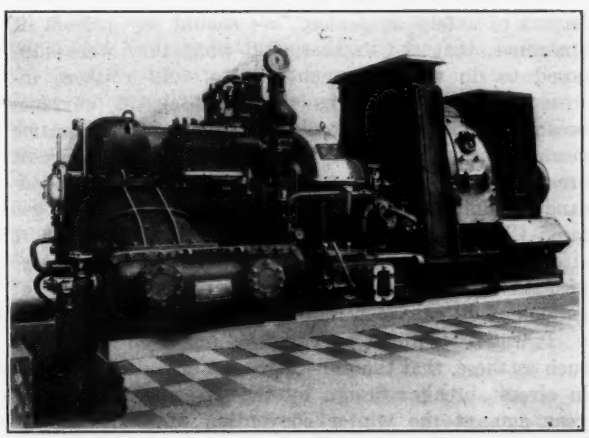
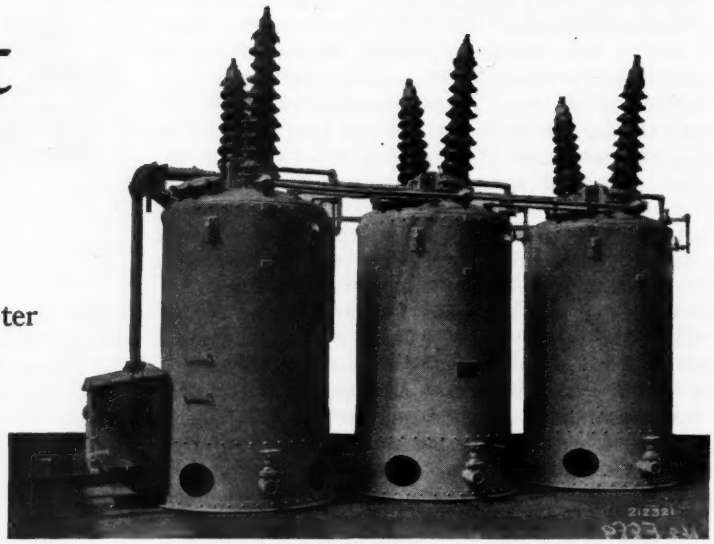


FIG. 3. IN THIS UNIT, RATED AT 300 KW., ONLY THE HOTWELL PUMP IS BELOW THE FLOOR LEVEL

Using Gas For Arc Rupture *in* Circuit Breakers

Papers presented at the Winter Convention of the A. I. E. E. throw new light on the theory of the oil circuit breaker and suggest new design. . . . . .



IT MAY seem strange that among all the complex problems against which the electrical engineer has matched his skill, one which has proved most baffling and over which operators and designers have probably lost more sleep than any other, is the simple problem of opening or breaking an electrical circuit. This is due, no doubt, to the fact that the simplicity of breaking a circuit is only apparent—that behind the bright spark produced in low power circuits or behind the devastating explosion which occurs when a high power circuit is interrupted, lies a complex phenomenon which only the most searching investigation and the most modern theories of electricity have been able to disclose.

Until quite recently, the design of circuit breakers and switches was largely a matter based upon experience often sad and always costly but without which no basis of design was available. As long as the power in circuits remained small, it was not difficult to make the parts of circuit breakers so rugged and with such large factors of safety or perhaps we should say factors of ignorance, that the breakers did what they were supposed to do without much trouble. As voltages increased, however, and as the short circuit currents became greater, the circuit breaker problem became more acute and as everybody knows today, a circuit breaker for a high powered circuit is a matter of thousands of dollars, and of the proportions of a young gas tank. In such breakers, the arc formed under short circuit conditions has all the characteristics of a score of wild cats and only massive steel and thousands of gallons of oil can keep it under a semblance of control.

It was not without reason, then, under circumstances such as these, that the announcement of a new principle in circuit breaker design by the Westinghouse Co., a year ago, at the winter convention of the American Institute of Electrical Engineers, was received with great interest by electrical men throughout the country. This was the Deion breaker, so named because it utilized the principle of rapidly deionizing the arc space as the alternating potential across the arc passed through zero value.

Dr. Joseph Slepian, under whose direction this breaker was developed, had for some years been making an intensive study of the electric arc and had discovered many things about it. He, of course, was particularly interested in the mechanism of extinction of the alternating current arc, since it is the alternating current arc with which we have usually to deal.

Extinction of the Short A.C. Arc

In presenting his theories, Slepian pointed out that the extinction or re-ignition of an a.c. arc following a current zero depended upon the outcome of a kind of a race between two contending factors, one depending principally on the arc space alone, and the other principally on the external circuit alone. The first is measured by the rate at which the arc space recovers dielectric strength as a result of disappearances of ions throughout the whole or certain favored portions of the arc space. The second factor is measured by the rate of building up of the voltage applied to the arc terminals by the external circuit and tending to re-ignite the arc. For determining this factor in extinction of the a.c. arc, the normal frequency, voltage, current and power factor are not enough to characterize the circuit. The transient characteristics must also be considered.

From this analysis, it follows that the interrupting capacity of an a.c. switch may vary considerably, depending on the nature of the circuit in which it is tested. This has been amply verified in the experience of those in charge of circuit breaker operation.

In the development of the Deion circuit breaker, it was shown that in the short arc, most of the recovered strength after a current zero, resides in a deionized

layer next to the cathode. Almost instantly after the current zero, a layer of gas immediately adjacent to the cathode becomes almost completely deionized and thus acquires some dielectric strength almost instantly. To carry any considerable current again, this space must be broken down, and being almost completely deionized, its new breakdown is quite similar as a phenomenon to the breakdown or sparkover of an ordinary un-ionized gas between metallic electrodes. This breakdown takes place through the mechanism of ionization by collision, and at ordinary pressures requires an electric gradient of the order of 10 to 100 kw. per cm.

Since even the thinnest layers of an un-ionized gas require several hundred volts to be broken down, the space next to the cathode acquires the ability to withstand such voltages almost instantly. The rest of the arc space loses ionization more slowly, and as its deionization proceeds, the deionized cathode layer increases in thickness. With this increase in thickness comes an increased dielectric strength of the cathode layer. Thus after the first few hundred volts, the cathode layer gains dielectric strength relatively slowly.

It was evident from this that if, in an arc which ordinarily could not be regarded as short, nearly all or at least a considerable amount of the arc space could be brought adjacent to the cathode, the dielectric strength of even such arcs would be regained almost instantly. This was accomplished in the development of the Deion breaker. In this breaker, the arc, after it is formed, is carried into a stack of metal plates, which serve as cathode surfaces to deionize the layers of gas adjacent to them. All this was presented at the winter convention of the American Institute of Electrical Engineers in New York a year ago.

Since that time, however, investigation and research has been continued and this year, at the winter convention of the American Institute of Electrical Engineers in New York, Dr. Slepian together with B. P. Baker and H. M. Wilcox, all of the Westinghouse Electric and Manufacturing Co., presented a series of papers on the theory and development of a breaker for long a.c. arcs. This new breaker incorporates the use of oil; in fact, it is a further development of the oil circuit breaker. Before we discuss this new breaker it will be of interest to discuss briefly the theories regarding the extinction of the long a.c. arc as advanced by Dr. Slepian.

The Long A.C. Arc

The long arc is one in which, during the extinction period, the larger part of the recovered dielectric strength resides in the space away from the cathode layer. In such an arc the space is highly conducting because of the intense ionization there. During the extinction period, following current zero, the ionization disappears, not suddenly but in a relatively gradual manner. The space then continues to have conductivity throughout the extinction period; nevertheless it has a continually increasing breakdown gradient defined as follows:

In an ionized space, ions are continually being lost in two principal ways: one, by direct recombination of ions of opposite sign within the space and the other by the passing of ions outside the boundaries of the space, by diffusion only, or assisted by electric fields, air blast, or other means. If the space is to maintain its conductivity, these losses of ions must be made up by some ionizing agent. Although their nature is not well understood, the ionizing agents capable of producing ions sufficiently rapidly to replace the losses which occur in an arc space are directly dependent on the impressed electric field, and the intensity of those ionizing agents varies with the intensity of the impressed field.

At any particular instant, there is a particular electric gradient for which the ionizing agents are just sufficiently intense to make up the ionization which is being lost in the arc space. If this gradient is impressed, the conductivity of the space will continue to maintain itself. If a smaller gradient is impressed, ions will be lost at a rate faster than that at which they are being generated and the space conductivity will diminish. If a larger gradient is impressed, the space conductivity will increase. This critical gradient at which the conductivity of the space just maintains itself, we shall call the breakdown gradient.

It was stated that in an arc, recovery of the dielectric strength is effected first by direct recombination of the ions in the space and second by the passing of ions outside the boundaries of the space by diffusion. If we can accelerate the rate at which either or both of these two processes occur, we shall increase the rate of recovery.

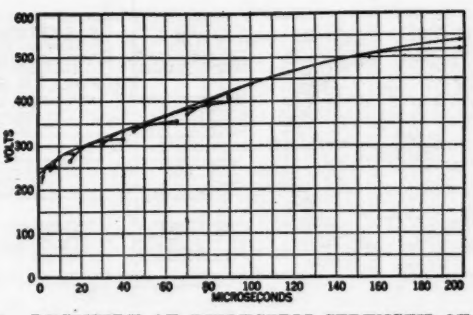


FIG. 1. RECOVERY OF DIELECTRIC STRENGTH OF ARC SPACE AT SHORT ARC VOLTAGES REQUIRED TO REIGNITE ARC IMMEDIATELY AFTER CURRENT ZERO IN AIR AT ATMOSPHERIC PRESSURE

It is evident, then, that to a certain extent, the rate of recovery of a given arc is dependent upon the cross section, since with a small cross section of the arc, the ions diffusing out will have less far to travel than they will if the cross section is large. This accounts for the known fact that the extinction of long a.c. arcs in holes or slots with insulating walls is easier than in the open. In experiments along this line, arcs were started by fine fuse wires in holes in soapstone, the external circuit consisting of transformers for which the transient time required to impress open circuit voltage upon the arc space after current zero was of the order of ten microseconds. With a hole 0.378 cm. diameter, and 3.81 cm. long, 545 amp. was interrupted in a circuit of 1150 v. r.m.s. A hole 0.193 cm. diameter and 2.54 cm. long also interrupted this current and voltage.

From these experiments, it was found that the voltage gradients after current zero were 228 and 456 v. respectively. Comparing these values with those for arc in the open, where for 60 cycles and currents of the order of 1000 amps., only about 50 v. r.m.s. may be interrupted per cm., it can be seen that the volts per

cm. which can be interrupted by an arc in a hole are much larger than for an arc in the open. An arc in a hole in an insulating material, therefore, recovers its dielectric strength much more quickly than an arc in the open. This is due to the fact that the walls of insulating material keep the arc's cross section down to the size of the hole.

Arcs confined to holes are used in completely closed fuses but usually the gases generated by the decomposition of the material of the fuse case play an important part in the extinction of the arc as will be shown. If an inert filler powder is used in the fuse, then the arc plays in the interstices between the powder particles and the arc is perhaps better described as playing in narrow slots. Arcs confined to small holes are little used in switches because of the difficulty of drawing an arc in such a place and the rapid destruction of the hole wall with use. Arcs confined to slots are, however, very generally used in switches, for the usual arc chute

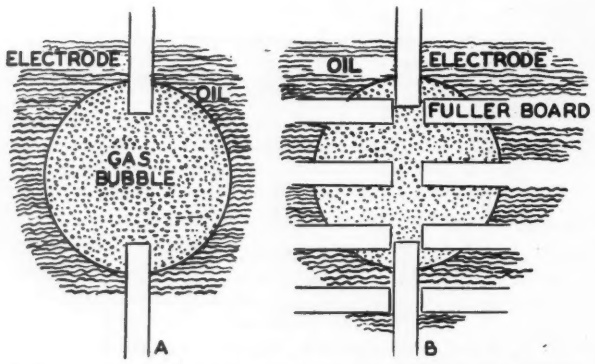


FIG. 2. DIAGRAM ILLUSTRATING EXPERIMENTS WITH OIL CIRCUIT BREAKERS. A GAS BUBBLE IN OIL CIRCUIT BREAKER. B GAS BUBBLE IN FULLER BOARD STRUCTURE IN OIL CIRCUIT BREAKER

in magnetic blowout switches is of restricted width and may properly be described as a slot. That the volts per cm. which may be interrupted are greatly increased by using a narrow arc chute is well known.

The Expulsion Fuse

Another interesting case is the usual expulsion fuse, where the arc plays in a cylindrical hole open at one end, the bounding wall being horn fibre. Quite high volts per cm. are interrupted by such fuses, much higher in fact than in holes in soapstone or some other inert material. For example, in a 1.58 cm. internal diameter fibre tube 2500 amp. at 60 cycles could be interrupted at 4000 v. per cm. length of tube, while under the same conditions in soapstone instead of horn fibre, only about 40 v. per cm. length could be interrupted.

From these experiments, it was evident that some other factor than the mere confining of the arc to the hole was responsible for the extinction of the arc. Measurement of the amount of wall material destroyed in the operation of the expulsion fuse revealed the nature of this factor. *This material is gasified.* In one test it was found that about 0.25 gr. of fibre was decomposed per half cycle of arc. Assuming that the decomposition of 1 gr. of fibre would give rise to 750 cu. cm. of gas at 0 deg. C., this would correspond to 187 cu. cm. of gas generated per half cycle. For this gas to pass through the 1.27 sq. cm. sectional arc of the tube in one half cycle, the gas would need to have a velocity of at least *180 meters per second.* At the higher temperatures in the arc, the velocity will be correspondingly higher.

Action of the Gas Blast

Thus, the extinction of the arc in the expulsion fuse depends for its action upon an intense gas blast generated by the decomposition of the material of the fuse case. A careful consideration of these matters showed why a gas blast through an arc so increases its effectiveness. The gas passing through an arc stream is in a highly turbulent motion, and at any instant and particularly at current zero there will be small volumes of fresh, relatively cool, un-ionized gas dispersed throughout the arc space. The recombination of ions in a cold gas takes place at a tremendously greater rate than in a hot gas. Thus the tiny volumes of cold gas scattered through the arc space act as nuclei which remove ions from the more densely ionized portions of the arc space, and then because of the lower temperature there, the ions which enter these cold nuclei spaces recombine at a much more rapid rate than they would in the hot gas which has just been carrying current. These small volumes of cold un-ionized gas present an immense internal surface at which deionization takes place in the arc space. We may say that the ratio of perimeter to area of the section of the arc space which is actually highly ionized at current zero, is enormously increased.

The Oil Circuit Breaker

This led to a study of this action in the oil circuit breaker. In the oil circuit breaker the arc which forms, plays in a gas bubble formed by the decomposition of the oil. Several theories have been advanced to show why an arc so confined under oil is so effectively extinguished after current zero is reached and while some of these factors employed in these theories are no doubt influential, they are all subordinate in Slepian's opinion to the part played by volumes of cool un-ionized gas in the arc space arising from the decomposition of the oil. This gas provides deionizing centers in which the ions in the arc combine with neutral atoms, and since these deionizing centers are relatively cool, re-combination of the ions proceeds with great rapidity.

That this is the principal cause of the arc interrupting capacity of the oil circuit breaker, seems overwhelmingly certain from the consideration of the action of arcs in holes and in the expulsion fuse. Here, then, is the secret of the oil circuit breaker. *The oil circuit breaker is a gas blast switch,* the gas arising from the decomposing oil.

This point of view leads to conclusions diametrically opposite to those usually held as to desirable and undesirable features in oil circuit breakers. From this point of view, the decomposition of the oil instead of beng entirely undesirable is the very feature which makes the oil breaker function. To improve the oil breaker, the rate of formation of gas should be increased, not decreased, provided of course that the gas formed is thoroughly mixed with the ionized gas which is carrying the arc. As a matter of fact, liquids more volatile than the usual switch oil are used quite successfully in certain types of fuses.

In the oil circuit breaker the attempt should be made to cause the oil to be decomposed at as rapid a rate as possible, and to cause the gases formed to pass turbulently over the whole section of the arc stream. In this way the length of arc needed for a given voltage will be reduced and the arcing time lessened, so that in spite of the increased rate of gas evolution per unit time and per unit length of arc, the total amount of gas generated in a particular switching operation will be lessened.

The growth of the gas bubble in the oil breaker is a factor which works against the extinction of the arc, because it causes the oil boundary to be at a considerable distance from most of the arc section, therefore causing the rate of decomposition of the oil to be reduced.

For the design of a more effective oil circuit breaker, the problem, therefore, is to bring about a more intimate contact between the oil and the arc. Any means which will prevent the oil-gas bubble surface from receding from the arc will aid in the arc extinction. This was found to be the case in the following experiment.

A two-break breaker of usual construction, with a 21.5-cm. stroke was used to interrupt 3500 amp. at 7620 v., 60 cycles. It was found that nearly the full length of stroke was needed, the average total length of arc being 40.5 cm. The extinction thus took place at a gradient of 188 v. r.m.s. per cm. of arc. See Fig. 2a.

The structure shown in Fig. 2b was then built around the arc path. It consisted of plates of fuller board, 1.26 cm. thick with a central hole 1.58 cm. in diameter, spaced 1.9 cm. apart. The two arcs were drawn in the central holes of the two structures. The fuller board was highly porous and of course became oil soaked. When the arc was drawn, a gas bubble was generated and the oil moved away from the arc. The oil soaked fuller board, however, was immovable, so it kept oil surfaces down in the heart of the arc in spite of the receding gas bubble boundary. The rate of gas formation must then have been greatly increased and this gas was thrown directly into the ionized gas. An improvement in the operation of the breaker was therefore to be expected.

This improvement was found. In the same circuit as above, the average total arc length for extinction was 16 cm. so that the gradient was 475 v. r.m.s. per cm., more than twice the gradient obtained when the structure was not used.

This principle, in brief, is the one utilized in the De-ion-Grid type of breaker. The development of this breaker was described at the recent A. I. E. E. convention in New York following the presentation of Dr. Slepian's theory and will be covered fully in the next issue.

DETERMINATION of the carbon residue content of a lubricant can be accurately made by a method adopted by the American Society of Testing Materials. This involves the external heating of a measured quantity of oil with a suitable arrangement of crucibles until all vapors have been driven off. The residue within the innermost porcelain crucible will be the carbon residue content of the original sample of oil. By careful weighing, it can be expressed as a percentage basis in relation to the oil under test. A more relative means to determine the extent to which a lubricant will develop carbon residue is the so-called hot-plate test, which is a practical qualitative test only.

Lamme Medal Awarded to R. E. Hellmund

LAMME MEDAL of the American Institute of Electrical Engineers has been awarded to R. E. Hellmund, East Pittsburgh, Pa., "for his contributions to the design and development of rotating electrical machinery." It is expected that the Medal will be presented at the Summer Convention of the Institute which is to be held in Toronto, Canada, June 23-27, 1930.

Rudolf Emil Hellmund, chief electrical engineer of the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penna., was born in Gotha, Germany, February 2, 1879. After receiving his early education in Gotha, he attended the Ilmenau Technical College, from which he graduated with honors in electrical engineering in 1898. He later took post-graduate work at the University of Charlottenburg.

Prior to his studies at Charlottenburg, Mr. Hellmund worked for some time as a designer of electrical machinery and spent one year in the laboratory of the Land-and-See Kabelwerke, Cologne. Subsequently, he was placed in charge of the test floor and laboratory of the Maschinenfabrik Esslingen, Stuttgart, Germany.

After his course at Charlottenburg, Mr. Hellmund came to the United States and was employed by the Krantz Co. of Brooklyn as a designer of switches and switchboards. In 1904 he was employed by William Stanley of Great Barrington, Mass., with whom he worked on the design of induction motors and also on experimental work on self-compounding alternators. Following this, Mr. Hellmund worked for the Western Electric Co. at Hawthorne, Illinois, designing a line of induction motors which was then marketed by that company. In 1907 Mr. Hellmund entered the employ of the Westinghouse Electric and Manufacturing Co. as a designer of induction motors. Later he was engaged in general engineering work and, in 1912, was placed in charge of the design of all direct and alternating current railway machines. In 1917, Mr. Hellmund was assigned miscellaneous consulting work, in which he continued until 1921, when he was appointed engineering supervisor of development. In 1926 he was appointed chief electrical engineer of the company.

In his engineering experience with the Westinghouse company, Mr. Hellmund developed new ventilating systems and stator structures of various types of machines, numerous control systems, new armature windings, regenerative systems for railways, control systems and structures for phase-converters and phase-converter locomotives, all of which are in practical use. He obtained in the neighborhood of three hundred United States and foreign patents covering various features of the above mentioned and similar subjects.

Mr. Hellmund is the author of many papers which have appeared in the Transactions of the American Institute of Electrical Engineers, and Proceedings of the British Institution, and various other American and foreign technical magazines, covering such subjects as rotating fields and leakage fluxes in a.c. machines, single-phase commutator motors, regenerative control for railways, electric traction, engineering education.

He joined the Institute in 1905, was transferred to the grade of Member in 1909, and became a Fellow in 1913. He is also a member of the German Electrotechnical Society.

Physical Factors in the Operation of Utilities

PART I. DETAILS OF METHOD USED IN ANALYZING FACTORS OF IMPORTANCE IN OPERATION OF ELECTRIC UTILITIES IN NEW YORK STATE, TO SHOW HOW METHOD CAN BE APPLIED TO ANY UTILITY COMPANY. BY ROBERT T. LIVINGSTON*

THIS IS THE first of several articles on the operation of the electric utilities in New York State. In making a statistical study of these utilities, the author is computing the various factors, costs and relationships which exist, in order to determine how they vary, to what extent they depend upon one another and what changes have occurred during the past 10 yr. From such a study, estimates may be made as to what is likely to occur in the future.

In the operation of any plant producing electricity or company selling it, much can be learned from a study of other companies or stations engaged in the same business and these articles attempt to present in a simple and clear manner the most pertinent costs, ratios and factors of those companies operating in New York State. The executives and operators will find ready yardsticks with which to compare the various phases of their operation and may possibly find the point where attention may most profitably be directed. Other studies of this nature have been made at various times in greater or less detail but almost without exception, such studies have been made of the 5 or 10 outstanding and largest companies in a district. The value of such studies is indubitable but the usefulness for the operator of a small company or plant is doubtful. The costs and ratios of a small company must of necessity be materially different from the costs and ratios of a large company. In this study, companies of all sizes, types and varieties are included from the large metropolitan companies to the small rural ones. Those companies operating in New York City have been omitted, as have those whose annual revenue is less than $50,000 a year.

TABLE I. PER CENT OF ELECTRICITY GENERATED AND/OR BOUGHT WHICH IS SOLD VS. OPERATING REVENUE AND PER CENT DOMESTIC AND COMMERCIAL LIGHTING SALES FOR YEAR 1917

YEAR 1917

% Sold	Oper. Rev. ÷ 1,000	% Light Sales	% Sold	Oper. Rev. ÷ 1,000	% Light Sales	% Sold	Oper. Rev. ÷ 1,000	% Light Sales
85.1	4,136	10.4	81.0	64	60.9	67.3	31	-
91.0	2,299	-	63.9	84	45.9	78.0	99	48.4
96.0	1,998	-	43.0	6	67.8	91.0	64	1.5
98.0	1,394	-	63.5	70	66.9	77.0	2,754	22.1
96.9	1,211	-	61.8	69	49.5	84.0	1,685	27.5
86.5	748	27.6	70.7	48	40.1	80.0	1,803	13.2
66.0	503	50.5	88.5	56	9.0	83.5	1,450	10.1
82.5	503	48.9	98.0	43	40.0	82.5	1,519	3.2
75.3	359	36.3	68.0	52	51.5	81.0	827	44.9
93.1	344	0.3	74.1	47	77.0	83.5	732	13.6
93.5	100	22.7	82.0	57	36.0	72.1	666	18.6
86.5	318	31.8	88.2	45	83.0	83.5	424	38.0
88.9	235	-	77.1	44	38.4	80.5	522	6.3
93.1	233	0.3	90.0	45	38.0	53.0	535	27.8
90.0	211	0.7	88.5	45	6.7	75.0	1,300	26.6
75.9	200	17.3	99.0	44	1.1	93.0	326	5.0
82.0	188	16.1	89.0	44	12.8	65.9	303	27.5
84.1	109	35.4	68.2	37	59.2	83.1	220	6.5
72.1	140	27.1	73.5	41	47.9	46.6	257	32.1
86.9	142	9.1	100.0	41	64.6	78.1	245	11.7
96.9	137	0.6	82.5	32	51.0	77.2	163	24.7
80.1	121	14.9	74.0	34	27.4	79.9	168	33.6
68.1	95	39.0	66.5	598	14.2	75.0	186	29.3
86.1	105	76.5	73.5	35	-	42.1	181	38.5
67.6	103	55.5	86.3	32	64.5	72.1	172	19.1
94.5	103	-	76.9	30	35.3	61.0	112	36.0
76.1	102	24.8	93.0	108	7.8	85.6	85	21.0
80.0	90	20.1	53.9	31	65.9	82.0	97	36.0
93.1	73	21.3						

The data were obtained from the Reports of the Public Service Commission of the State of New York for the years 1917, 1922 and 1927.

In determining the desired factors, common statistical methods were used. The ratios were computed on a slide rule and generally only three significant figures were used. In all cases, it was attempted to discover the "Mode" of the frequency curve and the range within which 50—60 per cent of the cases fell. When the Mode was not clearly defined, the "Median" was used and as a last resort the "Mean." These terms will be explained and the method of obtaining them. One complete case will be worked out and as all other cases were done in a similar manner, it will not be necessary to repeat in subsequent articles and they will be confined to a presentation of the results of the different studies and a discussion of the value of the factor and its variation with other terms. The tables and values given show first the number of cases used, second the usual value, which may be either the Mode, Median or Mean, then the range or the values between which all usual cases will fall and last comments or notations pointing out any peculiarities which may exist. Where a study brought out any interdependence between factors, this interdependence will be presented in graphical or tabular form.

TABLE II. METHODS INVOLVED IN OBTAINING THE MODE, MEDIAN AND MEAN

Class Interval	No. of Cases = N	No. from Model Class	Summation	Mid Point = M	M x N
0 - 49.99	3	37	3	omit	-
50 - 54.99	2	34	5	52.5	105.0
55 - 59.99	0	32	5	57.5	-
60 - 64.99	4	32	9	62.5	250.0
65 - 69.99	8	28	17	67.5	540.0
70 - 74.99	9	20	26	72.5	652.5
75 - 79.99	11	11	37	77.5	852.5
80 - 84.99	19	0	56	82.5	1,567.5
85 - 89.99	11	11	67	87.5	962.5
90 - 94.99	11	22	78	92.5	1,017.5
95 -100.00	7	29	85	97.5	682.5
	85				6,630.0

In order to illustrate the method used and the meaning of all the terms, one complete frequency distribution study is here presented. The ratio analyzed is the relation between the kilowatt-hours sold and the total to account for which is the sum of the generated and purchased. This factor indicates the amount of electricity which is lost or used by the company and is a measure of the distribution losses, the power factor and the condition of the customers' meters.

The Mode is the point at which there is the greatest concentration of cases. Table I presents these data for the year 1917 arranged for this study, the per cent sold, the operating revenue divided by 1000 and the per cent domestic plus commercial lighting sales to the total sales. Table II, the ratios—per cent sold—are collected by

*Assistant Professor Mechanical Engineering, Columbia University.

class intervals, each interval being 5 per cent, and it is seen that there is the greatest concentration in the 80—85 per cent class. This is best seen in Fig. 1, which is a graphical representation termed a histogram which is commonly used in statistical studies. This class—80—85 per cent—is called the Modal class because it must contain the Mode. The Mode must lie either above or below 82.5 per cent—the mid point—and it will be either above or below 82.5 per cent, depending upon whether there are more cases above or below the modal class. The method of determining its exact position is as follows:

The third column of Table II shows the number of cases from the Modal class and it is seen that there are 37 cases below and 29 above, therefore it is obvious that the Mode will be below 82.5 per cent. Its actual value is 82.2 per cent and is determined as shown:

$$37 + 29 = 66 \quad 29/66 = 0.44 \quad 0.44 \times 5 = 2.2$$
$$80 + 2.2 = 82.2 = \text{Mode for year 1917}$$

The Median is that point at which the number of cases is evenly divided; that is to say, there will be the

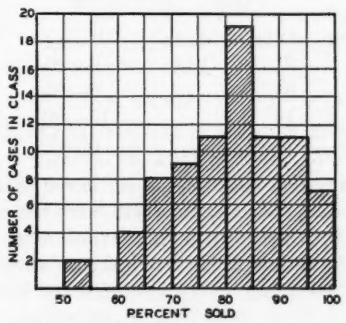


FIG. 1. HISTOGRAM SHOWING LOCATION OF THE MODE

same number of the cases above and below the point. In the illustrative example, there are 85 cases; therefore the 43rd will be the center point. Column four of Table II illustrates this. As with the Mode, the Median must fall in the 80—85 per cent class, as there are 37 cases below. There are 19 cases in this particular class, so that the Median will fall 6/19 of the way through the class or

$$43 \text{ (the center point)} - 37 = 6 \quad 6/19 \times 5 = 1.6$$
$$80 + 1.6 = 81.6 = \text{Median for the year 1917}$$

For all practical purposes, the Mean is the same as the average and it may of course be computed by adding up all the cases and dividing by the number of cases. It also may be computed, as has been done here, by class intervals. This is also illustrated in Table II. The mid point of each class is placed in the fifth column of Table II and this is multiplied by the number of cases in that class and the product written in column 6. The summation of this column (entitled M × N) divided by the number of cases (85) gives the weighted class Mean, which in this case is 78 per cent, which is quite different from either the Mode or the Median.

The range, which is used in the tabulations is the range of values between which the majority of the cases fall and, from Fig. 1, it is seen to be from 75—95 per cent.

STUDY OF PER CENT OF TOTAL ELECTRICITY SOLD

Year	No. of Cases	Prf. Position	Range
1917	85	82.1	75—95
1922	63	86.0	75—90
1927	60	86.1	75—90

It was next desired to discover whether there was any relation between the size of the company and the amount sold. For each year under consideration, the ratios were grouped together and the Mean of each group taken. This was done for the year 1917 as follows:

Class of Revenue	No. of Co.'s	Mean Ratio
Over $1,000,000	11	87.4
Over $500,000	9	72.3
Over $250,000	8	81.1
Over $100,000	23	84.4
Under $100,000	34	79.8

This is not conclusive and the other years were equally inconclusive but it does indicate that in general there is a tendency with the larger companies for the loss to be less.

Figure 2 shows graphically the relationship which was found to exist between the per cent lost and used—which equals 100—per cent sold and the per cent domestic plus lighting sales.

It appears that there has been a slight increase in the per cent of the electricity sold and the reasons for this may be many. The year 1917 was a war year and, in general, the utilities were more interested in meeting their power demands than they were in economies. Supplies were difficult to obtain and distribution systems were not rebuilt even though the copper was insufficient.

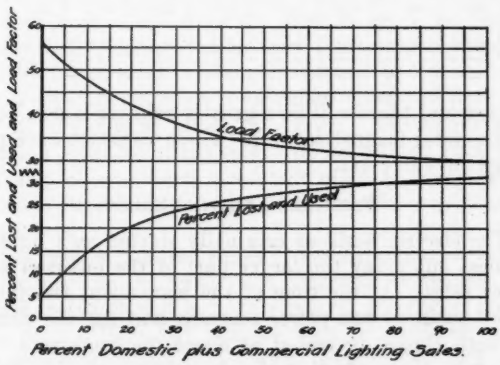

Load Factor
Percent Lost and Used
Percent Lost and Used and Load Factor
Percent Domestic plus Commercial Lighting Sales.

FIG. 2. CURVES SHOWING VARIATION OF LOAD FACTOR AND PER CENT OF POWER LOST AND USED

As has been pointed out there is a slight increase in the per cent sold as the size of the companies increase and in general the size of the companies has increased during the past 10 yr.; then, too, as well as the material growth there has been an increase due to the absorption of companies, 25 fewer companies having been analyzed in 1927 than in 1922.

LOAD FACTOR

The Load Factor has materially increased during the period under consideration.

Year	No. of Co.'s	Pfd. Position	Range
1917	76	37.7	25—45
1922	49	40.4	30—45
1927	39	45.0	30—50

The Load Factor depends both upon the size of the company and the type of business which the company does. Generally speaking, the Load Factor increases as the size of the company increases. The average of the 3 yr. for different classes of companies by size is as follows:

Revenue from Sales	Average Load Factor
Over $1,000,000	47.2
Over $500,000	43.1
Over $250,000	40.7
Over $100,000	40.8
Under $100,000	35.3

In a similar manner, the Load Factor varies with the type of the company, in general, the more domestic and lighting business the company does the lower is its Load Factor. This is also illustrated in Fig. 2. This figure brings out one more fact which is apparent upon reflection that the more lighting business a company does the more the loss will be because the Load Factor

TABLE III. LOAD FACTORS VS. SIZE, AND LIGHTING SALES

LOAD FACTOR VS. SIZE					
	1,000,000	500,000	250,000	100,000	0
1917	52.3	45.1	45.0	41.4	32.5
1922	41.3	32.9	33.4	31.0	33.3
1927	49.1	51.2	43.7	49.9	40.0
Aver.	47.2	43.1	40.7	40.8	35.3

LOAD FACTOR VS. LIGHTING SALES							
	0 - 5	5 - 10	10 - 15	15 - 20	20 - 30	30 - 50	+
1917	57.6	41.6	45.7	42.5	35.7	32.8	33.9
1922	35.1	43.4	38.9	39.0	34.2	34.1	29.1
1927	74.0	37.1	48.4	53.4	44.4	46.1	36.9
Aver.	55.5	40.7	44.3	44.9	38.1	37.7	33.3

is lower and there will be a greater relative loss in keeping the lines magnetized, etc. These variations are presented in Table III.

Per Cent Lighting Sales

The electric business originally started as a lighting business but today the larger part of the business is in power sales. At the time of the war, about two-thirds of the business was power business and for the next 5 yr., both classes increased at about the same rate. Of late years, the perfection of refrigerators, electric stoves and other household appliances have caused the domestic load to increase more rapidly than the industrial. This is illustrated below:

Year	No. of Cases	Pfd. Position	Median
1917	82	36.7	27.0
1922	72	36.0	20.0
1927	58	45.8	30.0

The fact that many small hydroelectric companies whose business was largely wholesale have been absorbed may possibly account for a portion of this increase.

Use Factor Study

The Use Factor is the ratio between the average output of a system and the capacity of its stations. In this study, all the capacity of each system was included, provided that capacity was in operation during the year. In general, it was found that the hydro Use Factor was distinctly higher than the steam Use Factor.

Hydro Use Factor

Year	No. of Cases	Mode	Range	Median
1917	25	..	25—45	40.0
1922	23	..	30—45	35.0
1927	36	..	25—45	31.7
All three	74	41.0	25—45	32.3

The size of the company has little effect upon the Use Factor although there seems to be a slight tendency for both large and small companies to be higher than the middle class. The capacity of the station, however, has a marked effect upon the Use Factor, the larger stations running well above the lower stations. For example, those over 50,000 kw. capacity run an average factor over 50 per cent while the small ones under 1000 kw. capacity seldom attain 30 per cent. The same is true about the per cent hydro capacity. Where the hydro capacity is the major portion of the total capacity, the factor is high while, where it is a small proportion, it is low.

Steam Use Factor

Year	No. of Cases	Mode	Range	Median
1917	31	13.0	5—25	15.0
1922	31	..	0—25	13.0
1927	15	..	15—20	16.0
All three	74	21.3	0—25	15.1

The steam Use Factor is much lower than the hydro Use Factor and the separate years were not at all clearly defined. There seems to be no variation with operating revenue but there is a distinct increase with capacity of company.

Capacity	Range of Use Factor
25,000 kw.	15—20%
5000 kw.	10—15%
Under 5000 kw.	5—10%

For companies buying no power and with all steam capacity, the Use Factor worked out very distinctly 13.3 per cent, which is to be compared with 41.5 per cent for hydro companies under similar conditions.

This completes the study of the physical factors of these utilities in New York State. The next article of this series, which will trace the costs and their variations and changes throughout the 10 yr., will appear in an early number.

One of the difficulties met with in the marketing of washed coal is the tendency to freeze in cold weather, making loading difficult and expensive.

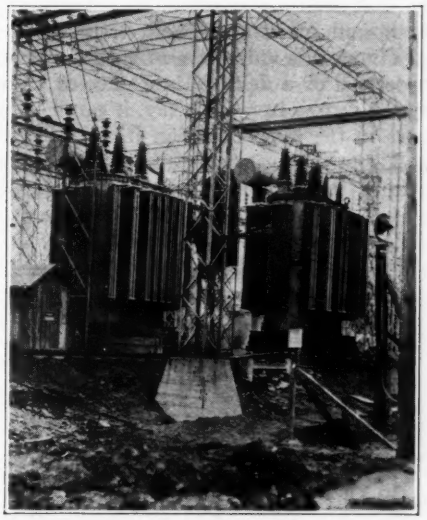
There are in certain districts special freight rates known as a "screening rate," which applies to coal of 0.2 in. and less in size. These rates in some cases are as much as 36 cents below the rates for larger sized coal and often mean a considerable saving in freight. Users do not always appreciate that these rates apply to small sizes of prepared coal as well as to screenings.

Finely divided lime and steam injected into boiler gases will prevent the discharge of sulphurous fumes from the stocks of power houses. By so doing, there is formed calcium sulphite and sulphate which can easily be arrested and recovered in suitable dust collectors.

ELECTRICAL PROTECTION *of* LARGE TRANSFORMERS

Part II

By E. H. Stivender



DIFFERENTIAL RELAYS are now being used for a great variety of applications. They may be grouped under the following headings: Bus differential, generator differential, transformer differential and line differential; generator and motor differentials are identical in their connections. Part I* of this series dealt with the more conventional types for transformer protection; the following is a discussion of special types and applications for the protection of transformers.

The Ratio Differential Relay

One of the late developments in differential protection is the scheme of the Westinghouse Electric & Mfg. Co. using ratio differential relays, there are a number of advantages which this system has over the standard current differential schemes heretofore discussed. Due to its principle of operation, the operating current continually flows through the relay coils, thereby causing the contact closing torque to vary in proportion to the load current. This principle, in many cases, prevents faulty tripping due to different current transformer characteristics when heavy through short circuits occur —since the ratio differential relay for transformer protection requires a minimum difference of 50 per cent in the two operating coils before the contacts will close. The standard differential relay systems using ordinary inverse time limit over load relays theoretically operate on constantly equal current transformer outputs, but due to the great difficulty of obtaining current transformers for the high and low tension sides which have the same characteristics, an inequality in ratios or characteristic curves will be greatly magnified on heavy overloads, requiring high time or current settings, thereby sacrificing some of the greatest advantages of differential protection.

For generator protection, the ratio differential relay differs from the transformer relay in having a minimum difference of 2.5 per cent for contact operation owing to the fact that the current transformers used are nearly always of like characteristics, being of the same voltage and current capacity and often wound type, which are much more efficient at all loads than bushing type current transformers. Also, it must be remembered that generator windings are not subjected to sudden inrushes of current in normal operation, as a transformer bank is when energized from full line voltage by the closing of an oil switch. The opportunity of using more sensitive relays for generator protection is nearly always taken advantage of, since transformers normally stand much more severe breakdowns than do generators.

Sometimes, for economical reasons, it is preferable to include the generator and transformer in one protective network and employ sensitive generator protection ratio differential relays. This is allowable where the generator supplies its own transformer independently without an oil switch in between, in which case voltage is built up on both sides of the transformer gradually, thereby avoiding the sudden energizing of one side, hence the destruction of current balance in the relays. In other cases, the generator differential scheme will include the generator only while the transformer and generator together will be included in another network, using transformer ratio differential relays.

In Fig. 1 (used in the preceding article but reprinted here for convenience) is illustrated a ratio differential relay for transformer protection. Coils 1, 2 and 3 produce a flux to act upon a rotating disk carrying the contacts; the flux to complete the rotating field is furnished by coils C and D from the induced current of A and B. Under normal conditions, the torque of coils 2 and 3 tends to hold the contacts in open position.

*Page 176, February 1, 1930 issue.

Should a fault occur between the two sets of current transformers, the difference of current in coils 2 and 3 is dispensed in coil No. 1; the magnitude of current in coil No. 1 of course depends upon the seriousness of the fault. All coils are so related to each other that when coil No. 1 is energized a torque is imposed upon the disk tending to rotate it and close the contacts of the circuit breaker trip coil circuit.

Figure 2 is a diagram of ratio differential relays for protection of a delta-delta connected transformer bank. By the arrows in No. 1 relay, it can be seen that current flows in the same direction in coils 2 and 3 and tends to flow in opposing directions in coil No. 1, therefore making the torque of coil 1 theoretically zero; these are the conditions for normal operation. When a short

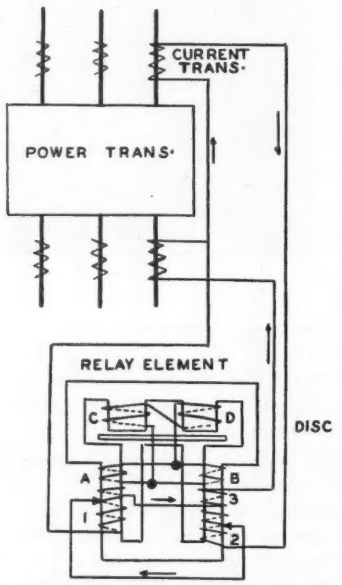


FIG. 1. A RATIO DIFFERENTIAL RELAY FOR TRANSFORMER PROTECTION

circuit takes place within the protected apparatus and there is a source of power on each side of the transformer bank, the currents in coils 2 and 3 will be reverse to each other and flow in parallel through coil No. 1, causing relay operation. If there is no source of power in one side of the transformer, the current in one of coils 2 and 3 will be zero and the remaining coil and No. 1 will be in series, also operating the relay but with about one-half the torque.

On generator relays the ratio taps are on coil No. 1 while those on transformer relays are on coils 1 and 2. These taps are in the form of two rows of removable screws. Coil No. 1 taps are brought out to one row while those of coil No. 2 are brought to the other. The action of the relay is such that the tap screw of one row must always be directly above that of the other row, in order that the torque of coil No. 1 will at all times vary in proportion to that of coil No. 2.

Ratio taps on the transformer relay are of value in the elimination of auto-current transformers. This can be seen from the following practical example:

The transformer to be protected is a 2300 to 66,000-v., 4000-kv-a., 3-phase unit, connected delta on the 2300-v. side and Y on the 66-kv. side. The current transformers on the 2300-v. side are in the transformer bushings with taps brought to the outside of the tank, the total secondary winding containing 218 turns with a primary rating of 1600 amp. Those on the 66-kv. side are in the oil switch bushings, of 100/5-amp. rating with a half winding tap brought out of the secondary. The ratio of the power transformer windings will be 66,000/(2300 $\times$ 1.732) or approximately 17/1. Since full load current on the 66-kv. side is about 35 amp. the center taps on the oil switch bushing transformers are the ones selected, giving a ratio of 50/5 for these transformers; then, with 50-amp. load on the high tension side, there will be 50 $\times$ 17, or 850 amp., on the low tension side—the low side current transformers being in the power transformer bushings will carry winding current and not the full 2300-v. line current. Therefore, selecting the 198 turn tap on the 2300-v. side, we have a ratio of 198/1, or 850/4.3. Hence, with a 50-amp. load, on the 66-kv. side, there must be 5 amp. flowing in one coil of the relay while 4.3 amp. are in the other. The ratio taps of the transformer ratio differential relay run, thus, 5/5, 5/5.5, 5/6, 5/6.6, 5/7.3, 5/8, 5/9 and 5/10 amp. Now that there is a ratio of

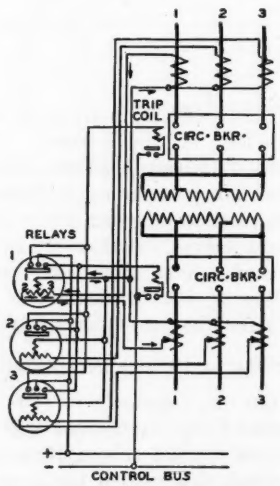


FIG. 2. RATIO DIFFERENTIAL RELAYS APPLIED TO THE PROTECTION OF A DELTA-DELTA CONNECTED TRANSFORMER BANK

4.3/5 amp. to be compensated for, it must be resolved into the ratio 5/5.8; the nearest corresponding tap setting on the relay is 5/6, which would be the correct ratio setting to be used. Care must be taken to run the larger current through the larger, or 10 amp. coil of the relay which is coil No. 2, Fig. 1.

The efficiency curve of bushing current transformers shows their ratio to vary considerably when operated on a primary current very far below their rating but, due to the rating of the current transformer in this case being above the full load rating of the transformer, unbalance in the relay currents at normal loads will not cause false operation and with a heavy through overload the differential currents will more nearly approach a balance point, so that only a fault within the transformer will bring about relay operation.

Figure 6 shows this type of relay connected for protection of a delta-delta bank of transformers with its circuit breakers, using multi-ratio current transformers

on one side of the bank. With this system, the current transformers can be of standard ratio making computation of the ratio settings of the relays comparatively simple, since the power current ratio and therefore the curent transformer secondary current ratios will be the same as the voltage ratio of the transformer bank.

The Split Conductor Method

Another form of differential protection is that shown in Fig. 3, sometimes known as the split conductor method. This scheme has a number of advantages over any other method of transformer differential protection although it is not so generally used as those heretofore discussed, owing to the greater expense of double winding high-voltage transformer construction, and the necessity of using 12 current transformers with six relays (or three relays and three auto current transformers), for protection against all degrees of faults. Owing to the fact that the high and low-side current transformers do not operate in series, very sensitive time and current settings can be used, because copper and iron losses cannot cause appreciable unbalance; however, it is not always practicable to use zero time and current settings due to circulating currents of relatively low magnitudes being sometimes present in parallel connected windings of this type. A circulating current, as can be seen, would cause the two current transformers of the two windings under consideration to feed in parallel through their corresponding relay, which, if set too low, would cause faulty tripping.

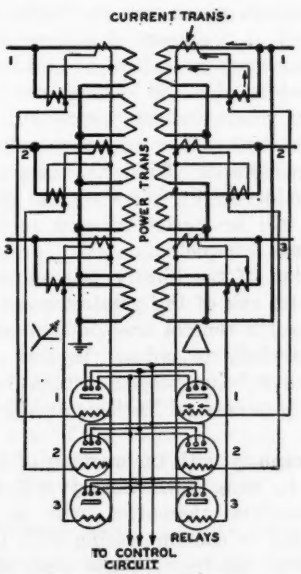


FIG. 3. SPLIT CONDUCTOR METHOD OF DIFFERENTIAL PROTECTION

Protection against open circuits in the windings and high resistance grounds is another advantage of this system over the standard current differential scheme, besides being independent of phase angle differences on heavy through short circuits, but at the same time the split conductor scheme cannot give protection for the oil circuit breakers.

In special cases, the current transformers on one side may be eliminated, thereby eliminating one set of relays. For instance, when there is a source of power on only one side of the bank, current transformers will be required on the source side only. This does not always hold true, however, for a fault on the load side; for, with transformers of low reactance, a low resistance short on one of the low side windings may cause ample saturation in its phase-core to effect a near balance in the two primary parallel windings (which contain the differential current transformers), hence producing insufficient torque to operate the relays.

The Power Differential Scheme

The wattmeter or power differential scheme, though sometimes used, has little advantage if any over current differentials. It employs the principle of balancing the output against the input of a power transformer, and when this balance is destroyed the circuit breakers are opened by contacts operated by the two wattmeter elements of the relay; besides the high cost of potential transformers for the high and low sides, a great disadvantage of this method is that it does not always discriminate between heavy through line overloads and transformer short circuits because sometimes copper losses greatly affect the balance watt input and output of a transformer; for instance if copper losses are 1 per cent at full load current, they will be 100 per cent at 10 times full load current.

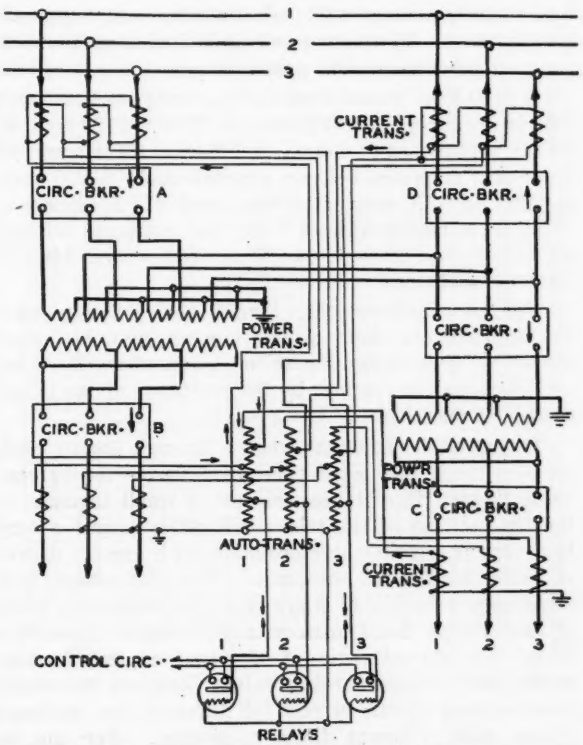


FIG. 4. PROTECTIVE SCHEME USING A COMMON DIFFERENTIAL SYSTEM FOR CLEARING FAULTS IN TWO TRANSFORMER BANKS

In Fig. 4 is shown a protective scheme using a common differential system for clearing faults in two transformer banks. Auto transformers are required in this system due to the Y-delta connection of both banks. It is not always necessary to have a relatively high current

setting on the relays due to different changes in the distribution of load through the two banks, because the current transformers of all secondary loads are balanced against the current transformers of the main supply circuit breaker A. Arrows indicate the instantaneous directions of currents.

Sometimes the reactance of the transformer must be known in order to determine definitely the current and time settings of relays for differential protection—especially where current transformers of different characteristics are employed, since on through overloads the peak current can often be computed successfully by knowing the transformer and line reactance. Transformer reactance varies from 3 per cent to 15 per cent while generator reactance varies from 5 per cent to 30 per cent. A 3-phase short circuit on a transformer of 3 per cent reactance will pull instantaneously approximately 10 to 15 times rated full load current with constant potential on the primary side.

A 1000-kv-a. transformer of 3 per cent reactance will deliver approximately 8770 amp. at 2200 v. 2920 amp. at 6600 v. and 292 at 66,000 v. A 300-kv-a. transformer of 3 per cent reactance delivers approximately 26,250 amp. at 2200 v., 8770 amp. at 6600 v. and 877 at 66,000 v. A 500-kv-a. transformer of 3 per cent reactance delivers 43,750 amp. at 2200 v., 14,600 at 6600 v. and 1460 at 66,000 v. and so on.

For transformers other than 3 per cent reactance, the approximate short circuit current may be determined by multiplying the values given above by three and dividing the product by the reactance of the transformer in question.

Owing to the fact that when a through short circuit remains for a prolonged time on a feeder the current value flowing into it becomes less, a small increase in the time setting of the relays will often permit a very low current setting, therefore allowing a greater degree of protection for the equipment. For this reason, it is sometimes valuable to know the line reactance when setting relays for transformer differential protection when the characteristic of the current transformers used differ. The following values illustrate the variations in short circuit current for different line reactance values with different times considered. For line to neutral short circuits:

A line of 10 per cent reactance delivers 27.1 times full load current for zero seconds, 6.63 times full load current for 1 sec. and 5.10 for 3 sec.

A line of 20 per cent reactance delivers 12.8 for zero seconds, 4.95 for 1 sec. and 4.51 for 3 sec.

One of 75 per cent reactance delivers 2.54 for zero seconds, 1.42 for 1 sec. and 1.4 for 3 sec.

For line to line short circuits: A line of 10 per cent reactance delivers 17.75 times full load current for zero seconds, 3.24 for 1 sec. and 2.0 for 3 sec. A line of 20 per cent reactance delivers 9.01 for zero seconds, 2.38 for 1 sec. and 1.88 for 3 sec. One of 75 per cent reactance delivers 2.36 for zero seconds, 1.05 for 1 sec. and 1.0 for 3 sec.

For the most reliable service, no instruments, such as ammeters or wattmeters, should be connected in the differential current transformer circuit. If instruments should be in this circuit, the total load on one standard current transformer should not exceed 30 volt-amp. and the unbalance should never exceed 10 volt-amp. Ammeter switches should not be in the differential circuit in any case, for the difference in resistance of the contacts when operating may cause an unbalance resulting in the tripping of the circuit breakers.

Grounding of instrument transformer secondaries at the transformer wherever possible is recommended in all cases, in order to afford protection in case of insulation breakdown and to neutralize the effects of electro-static induction.

Detroit to Have Great Machinery Library

LARGEST AND MOST COMPLETE machinery library in America if not in the world, archives where complete information concerning the machinery in use in all industries, which will give decided impetus to the movement to operate American industries along scientific methods will be established at MacDonald Brothers Engineering Laboratories, Inc., according to recent announcement by H. E. MacDonald, vice-president and general manager of the laboratories organization.

The laboratory, which will be erected at 1500 Oakman Boulevard, in the heart of industrial Detroit, will also contain a permanent exhibit of all kinds of machine tools and allied supplies. It is sponsored by MacDonald Brothers, Inc., production engineers with headquarters in Boston and with offices in several of the principal cities of United States. Kidder, Peabody & Co., financiers, have endorsed it. Work on the construction of the building will be started as soon as the architects' plans have been completed.

The creation of the library, according to Mr. MacDonald, will fill one of the greatest needs of American industry. Such a central encyclopedia of information will help materially to reduce the loss of millions of dollars that are being wasted annually by industry through the purchase of inefficient and obsolete machinery.

"Simultaneously with the opening of the laboratory, next year," he says, "the library will be completed. Factory executives thereafter will be able, either through visiting or communicating with the library, to obtain complete information not only about machine tools in use in their respective trades but in any and all industries. Such information as the library will collect, will save many concerns thousands of dollars annually.

"Through the absence of such a library, thousands of units of machinery are purchased abroad that should be bought here, often at a tremendous loss and delay to the purchasers.

"The library will not only be of untold value to the purchasers of machinery and allied supplies but will be of great educational value to the technical schools and colleges of the country, whose teachers and students will be allowed the use of its service free of charge."

VOLATILES, which contain from 20 to 45 per cent of the heating value of coal, are distilled off on the grate and these gases must be thoroughly mixed with the proper amount of air and burned close to the fuel bed before they have an opportunity to break down into their component parts and form soot.

MACHINE DRIVE—

Both Machine and Power Supply Must Be Considered

THE PROBLEM CAN BE VIEWED FROM THIS STANDPOINT WITH THE KNOWLEDGE THAT EQUIPMENT IS AVAILABLE TO MEET ALL THE CONDITIONS THAT MAY BE SPECIFIED WITH ALMOST EQUAL EFFICIENCY

MACHINE DRIVE, a matter of prime importance to the plant engineer, has of recent years assumed increased importance because of the introduction of economical and efficient small prime movers and improvements made in power transmission equipment.

Instead of the simple belt or chain from a line shaft driven by a steam engine or water wheel, the proper drive must be selected from a dozen or more possibilities in which the machine itself must be given prior consideration.

That is, all types of drive have been perfected to the point where, except in unusual and large installations, the differences in the actual power consumption are of less importance than the effect of the drive on the output of the driven machine. For instance, with a certain machine tool drive, the positive chain drive with no slip may mean an increased output of 5 or 10 per cent greater than a belt drive while, in another location, say a rock crusher, the greater flexibility of the belt drive might reduce the starting shock on both prime mover and driven machine materially and result in lower maintenance and longer life.

The most important feature is how the drive fits in with the characteristics and other features of the particular plant. In one place, a belt from a countershaft may be entirely satisfactory, while across the room in the same plant, the saving of an individual motor drive may save the cost of the motor monthly, solely because the machine may be placed in a better light enabling the operator to work to better advantage.

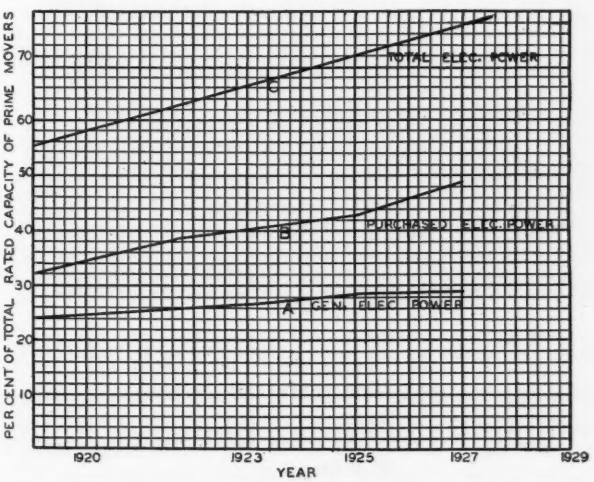
AVERAGE INDUSTRIAL MOTOR RANGES FROM 9 TO 14 HP.

In all industries, the tendency is toward individual drive. This tendency has been accelerated by improvements in power plant practice and the corresponding decrease in electric power costs. Increase in electrical motor applications is shown in curve drawn from data tabulated in the Census of Manufacturers. This data covers the years 1919 to 1927 inclusive and shows that in 1927 electric motors amounted to almost 76 per cent of the prime mover capacity in industrial plants. The average size of motors driven by purchased power is only 9 hp. while the average size of motors driven by power generated in the plant is around 14 hp.

This data does not, of course, differentiate between individual drive and group drive, a matter of some concern to the plant engineer. In portable machinery and equipment used where production methods are changing and many rearrangements are necessary, individual motor drive is favored; in fact, any machine where the average load is reasonably near the maximum and the starting load is not excessive, should be considered for individual drive.

An ideal group drive, on the other hand, is a number of machines with widely fluctuating loads where the peak occurs at different times. A motor rated slightly larger than the average load will carry them all. The motor used in this way operates with a high load and correspondingly high power factor in contrast to the usual low power of the individual motor.

Penalties for low power factors and high peak loads have done much to increase the popularity of group drive. In addition, larger motors cost less per unit of



INCREASE IN THE USE OF ELECTRIC MOTORS FROM 1919 TO 1927

power and are more rugged so that in many cases there is a certain advantage of lower first costs and lower maintenance.

Motors are not by any means the only small prime movers used as the use of small modern steam turbines is steadily increasing, internal combustion engines on small units are being widely adapted, especially in portable machines and even air motors have certain applications.

STEAM TURBINE DRIVE HAS MANY APPLICATIONS

In industries where low-pressure steam can be used either for heating or process work, the steam turbine forms an ideal drive easily controlled, reliable, efficient and rugged. Paper machines are good examples of this type of drive, the exhaust steam being used for drying.

Such a combination allows the steam to be distributed at high pressure, through comparatively small steam mains, gives the advantage of steam drive flexibility and reliability and byproduct power. This practice has been developed to its fullest extent in certain

byproduct coke plants. Practically all the drives in the plant can be turbine driven, the steam generated in the boiler house at 200 or 250 lb. pressure being distributed at boiler pressure, the exhaust from the turbines used in the process or for heating, any excess steam demands being made up from live steam.

Of course, even after the prime mover has been determined, there is the question of direct connection, gears, belts or chain drive to determine. Direct connection through flexible coupling is extensively employed where the machine speed can be made to correspond to standard motor speeds.

Direct Connection, Belts, Chains and Gears All Have Their Application

At the present time, there is a tendency toward this type of drive in machine tools and particularly in wood-working machinery, where extremely high speeds are demanded, motor speeds of 7500 r.p.m. being attained by the use of 125-cycle current. This adds somewhat to the electrical system by requiring frequency changers and additional wiring.

SOME OF THE MORE COMMON DRIVES USED THROUGHOUT THE PLANT

A. Type of prime mover
   1. Electric Motor
   2. Steam turbine
   3. Steam engine
   4. Internal Comb. Engines
   5. Hydraulic turbine
   6. Air motors

B. Type of drive
   1. Individual drive
   2. Group drive

C. Type of transmission
   1. Direct coupling
   2. Belt
      1. Long centers
      2. Close belt
      3. V belt
   3. Chain, silent or roller
   4. Line shaft and pulleys
   5 Gears
      1. Spur or herringbone
      2. Worm
   6. Variable speed units
   7. Rope drive
      1. English
      2. American
   8. Combination of Methods

Belts are used extensively for connecting the drives to the driven machine or shaft and where space is not limited are the cheapest and most logical method. Close belt drive where an idler pulley is used to increase the contact arc of the pulleys has done much to maintain the popularity of belt drive. Recently, the introduction of the V-belt has added further to the popularity of belts for close centers.

For positive drive with no slip, various chain drives are available and in successful operation on machine tools, miscellaneous apparatus and line shaft drives. Ratios of up to 7 to 1 are practical on short centers. Chain drives are particularly applicable where exposure to moisture, steam, high temperature and corrosive atmosphere cannot be avoided.

Gears and Speed Changers Answer Many Needs

Where reductions in excess of that given by chains or belts are needed, the gear reduction drive may be used. Ratios of 50 to 1 and 100 to 1 are common. Spur gears and worm gears are available and these units have reached a high state of perfection. Speed reducers are sometimes built integral with the motor.

When variable speed is desired from a constant speed prime mover, speed changers giving a considerable range of speed are available; some of these operate in definite steps while others give any desired speed between definite limits, either with manual or automatic control.

Rope drives are not as common as they once were but are still in use. The American system uses a continuous rope with the slack side forming a loop over an idler sheave and a tightener which maintains a definite tension on the rope. The English system uses separate endless ropes depending upon the weight of the rope and pinching in the grooves for traction. The modern V-belt multiple drive is similar in design to the English rope drive.

Engineer Must Watch Power Factor

Frequently it is economy to use a combination of various drives to accomplish certain operations economically and in limited space. Space, speed ratios, service, methods of control, power source, efficiency, convenience and initial costs are all factors which tend to influence the choice of equipment.

From the standpoint of the power plant, it is necessary carefully to watch the balance between the electrical load and steam load, especially so if no condensing equipment is provided. With motor drive, the resultant low power factor from under loaded motors and peaks from simultaneous starting of many motors must be kept in mind.

A.S.M.E. Petroleum Division Program

Petroleum Division of the American Society of Mechanical Engineers, organized in 1925, has a registration of 1300 and plans an ambitious program for its annual meeting in Tulsa, Okla. This will be held in October, 1930, at the time of the Petroleum International Exposition. The division also plans the formation of special committees to study special mechanical engineering problems, as follows: Production, Oil Transportation, Gas Transportation, Refining, Lubrication Engineering, Utilization as a Fuel. The Petroleum Division intends to coöperate closely with the Technical Divisions of the American Petroleum Institute and other organizations that are interested in the petroleum field.

Inherent moisture of coal varies with the kind of coal, average value being: eastern bituminous, 2 to 4 per cent; Pennsylvania and West Virginia, 4 to 10 per cent; Midwestern, 8 to 17 per cent; sub-bituminous, 12 to 30 per cent, and lignite, 25 to 45 per cent. The moisture content is the distinguishing feature between sub-bituminous and lignite.

Lincoln Oil Refinery Installs New Boiler

UNIT OF 607-HP. CAPACITY IS FIRED BY PULVERIZED COAL, BURNED IN FURNACE HAVING WATER-COOLED SIDE WALLS AND AIR-COOLED FRONT WALL UNDER PRESSURE

TO PROVIDE additional steam to meet the demands of its growing refinery at Robinson, Ill., the Lincoln Oil Refinery Co. has recently installed in its boiler house a new pulverized-coal-fired boiler. The other boiler equipment in the plant, described in the May 1, 1927, issue of Power Plant Engineering, consists of three V-type water-tube boilers, fired by chain grate stokers, the furnace side walls being water-cooled.

As previously noted, this plant follows many of the up-to-date central station practices in use of water-cooled furnace walls, air preheaters and extraction turbines. One of the principal features of the plant is the method of loading coal to the bunkers by hauling the coal cars up a long incline to the top of the boiler house and dumping them directly into the bunkers.*

In the new boiler installation, advantage was taken of the latest practice in burning pulverized coal, as carried out in some of the best modern plants in the Middle West. Figure 2 shows the resulting design of boiler, furnace and accessories. One of the most difficult problems in designing this unit was to make it fit into the space that had been left in the boiler room for a fourth stoker-fired unit; this has been accomplished, however, with no important changes in the steel-work.

DETAILS OF BOILER AND FURNACE

This new boiler, a Babcock & Wilcox 4-drum, bent-tube boiler of a new type, has 6074 sq. ft. of heating surface in the boiler proper, designed for 250 lb. operating pressure. Steam is superheated about 150 deg. to 550 deg. total temperature by a Babcock & Wilcox superheater in the first pass, as shown. At 100 per cent of rating, figured on boiler heating surface, this unit is designed to produce 20,000 lb. of steam an hour. It is designed for maximum production of 80,000 lb. an hour and a continuous production of 60,000 lb. an hour, corresponding to 300 per cent of rating.

Pulverized coal is fired in a water-cooled furnace with a volume of 4180 cu. ft., designed for a heat release of about 22,000 B.t.u. per cu. ft. per hr. Furnace side walls, rear wall and hopper bottom walls are covered with Fuller Lehigh Co. Bailey water walls as shown. This wall consists of tubes covered with cast-iron blocks to produce a continuous flat surface. On the sides of the hopper bottom and on the lower part of the side walls, the cast-iron blocks are of special type with rough surface, designed to allow a certain amount of slag to accumulate on them to a depth depending on their position and on the rate of operation, thus producing the effect of a refractory facing. When the rating of the boiler is increased, however, the increased heat in the furnace melts some of this slag from the block, thus increasing the heat transfer through it. The front wall is a Detrick, hollow, air-cooled refractory wall, the use of which will be described later. A Detrick suspended arch slopes up from the top of the air-cooled wall to the boiler drum.

*Power Plant Engineering, May 1, 1927, page 525, Fig. 1.

Coal for this furnace is pulverized by a Kennedy-Van Saun air-swept ball mill of 7500 lb. an hour capacity, driven at 30 r.p.m. by a 75-hp. Fairbanks-Morse slip-ring motor. The mill is designed to pulverize 85-90 per cent through 200 mesh and all through 50 mesh. Since the feeder of this mill is the part in which the operator is most interested, this feeder, with its ¼-hp. F. M. variable speed driving motor, is located on the operating floor, feeding Illinois 12,500-B.t.u. coal from the bunker overhead to the pulverizer mill in the basement below.

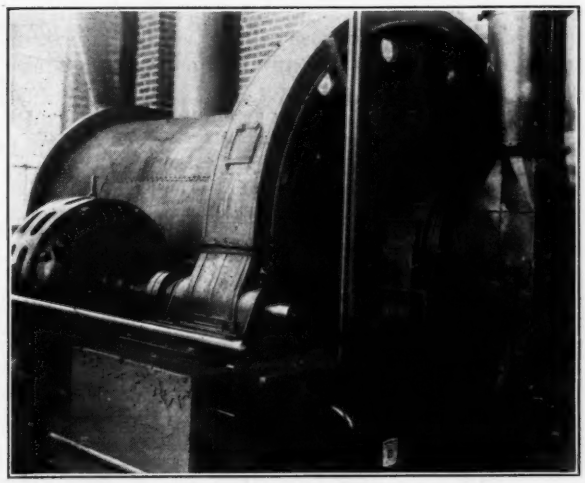


FIG. 1. AIR SWEPT BALL MILL, IN BASEMENT IN FRONT OF BOILER, CAN PULVERIZE 7500 LB. OF COAL AN HOUR

An exhauster driven by a Fairbanks-Morse 15-hp. slip-ring motor and located on the firing floor as shown, between the feeder and boiler, draws pulverized coal from the mill and feeds it to the Kennedy-Van Saun, Aurora-type turbulent burner set in the hollow front wall. This burner has a water-cooled nozzle and is designed to produce intense turbulence, short flame and complete combustion.

Ash from this furnace drops through the water-cooled hopper bottom to an A-S-H ash hopper, where it is quenched by water sprays, then is discharged through an Allen-Sherman-Hoff oil-operated ash gate direct to trucks or to a railroad car.

Flue gas is drawn from the boiler by the induced draft fan through a Babcock & Wilcox tubular 4838-sq. ft. air preheater of the counterflow single-pass type. The induced draft fan is a Sturtevant multivane 51,000-c.f.m. unit driven by a 75-hp. Westinghouse variable-speed motor.

Combustion air is forced through the air preheater, which can heat it to about 400 deg. if necessary. The forced draft fan is a Sturtevant turbovane 24,000-c.f.m. fan, driven by a constant-speed 40-hp. Westinghouse motor. This combustion air passes from the air preheater through the duct, shown running over the boiler.

to the top of the air-cooled front wall, through which most of it flows. At a temperature of about 350 deg., it emerges around the pulverized coal burner as secondary air. For primary air supply and mill drying air, about 30 per cent of the air is taken off from the duct where it enters the top of the air-cooled furnace wall. This primary air is led to an air header just under the firing floor, whence two pipes carry it to opposite ends of the pulverizing mill.

regulators on the boiler feed pumps provide for the automatic features of operation while Bailey meters and draft gages and a Ranarex CO_2 recorder give complete data on operation. Crane safety valves, Diamond soot blowers, B. & W. and Everlasting blowoff valves, Reliance water columns, Power Piping Co. piping and Crane high-pressure steam and water valves are installed. Geo. Allen & Sons erected the boiler setting.

For feedwater treatment, a Paige & Jones 4560-

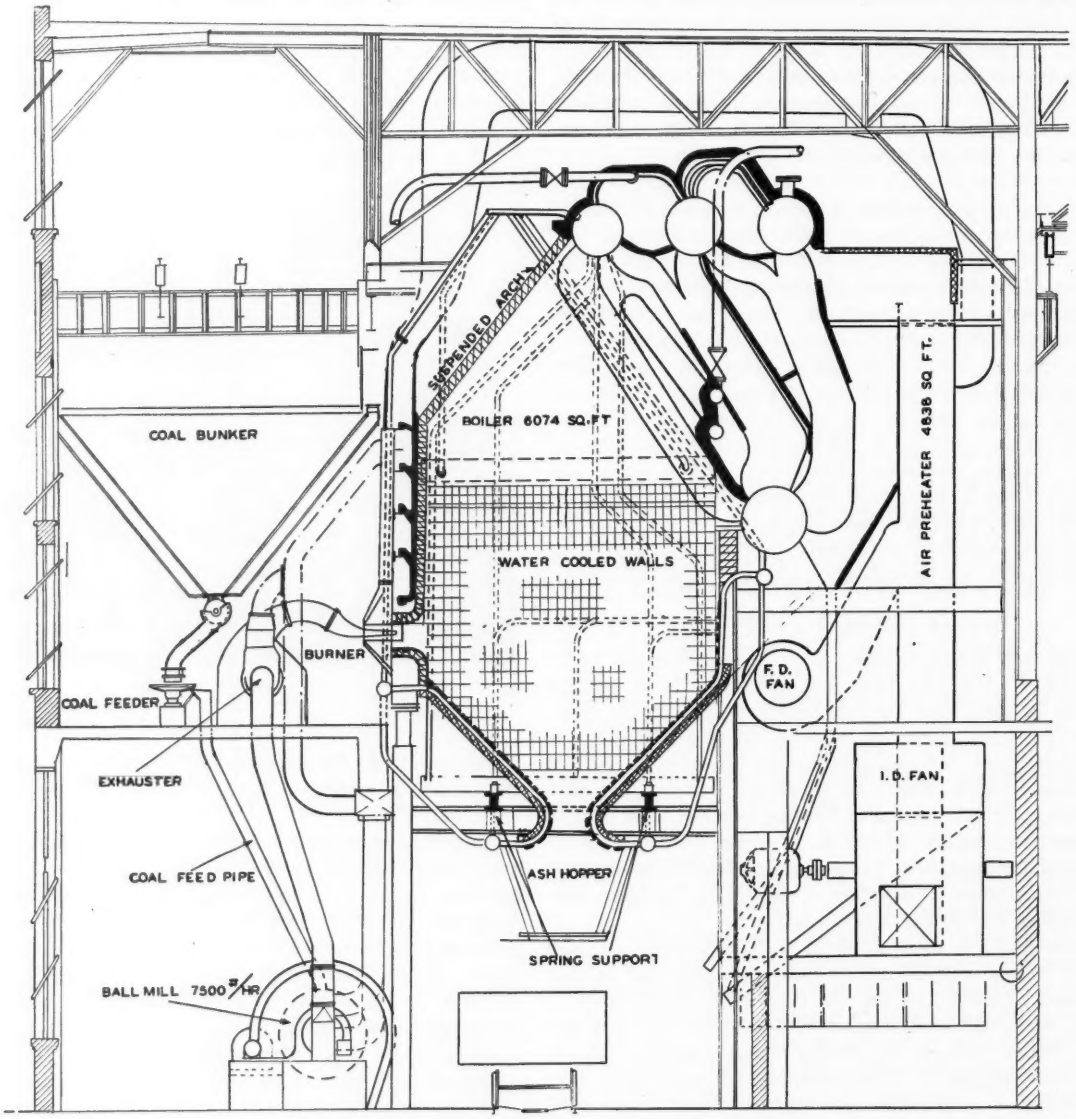


FIG. 2. CROSS-SECTION THROUGH NEW BOILER UNIT AT LINCOLN REFINERY, SHOWING FURNACE CONSTRUCTION AND ARRANGEMENT OF MILL AND AIR PREHEATER

It will be noted that, with this arrangement, the air is forced through the hollow furnace wall under a pressure of about 3.5 in. of water, instead of being drawn through under a much lower pressure as is the usual practice. A hollow furnace wall taking air in this manner is certainly unusual but it has proved entirely successful in this case, it is stated.

Stets feedwater controllers, Carrick combustion control regulating air to mill and exhauster speed by furnace conditions, and Mercon constant excess pressure

g.p.h. water softener was installed, together with a Cochrane 12,000-g.p.h. pressure filter that takes all condensate and trap returns before they go to the heater.

This new boiler and setting was designed and its erection supervised by Lincoln Oil Refining Co., of which H. B. Carpenter is vice-president, R. T. Luton is general superintendent, Geo. W. Uzzell plant superintendent, R. H. Nicholson chief engineer, and E. C. Minor power plant engineer in charge of boilers and power plant.

MULTIPLE EFFECT REFRIGERATION

By N. H. HILLER, JR.*

A Discussion of the Characteristics of the Multiple Effect Compressor and Its Advantages in the Modern Refrigeration System.

IN PRINCIPLE, multiple effect refrigeration is not new. Many years ago, a process using a multiple effect compressor was patented by Gardner T. Vorhees. Mr. Vorhees' compressor, however, was not of the same pattern as those used today in that it had mechanically operated suction and multiple effect valves. There was some trouble in operating such valves and the original multiple effect compressor never was widely used.

The multiple effect compression system compared to the simple compression system, is shown in Fig. 1. It provides for the filling of the compressor cylinder from a low pressure suction line, then supplementary filling near the end of the suction stroke with high pressure gas taken either from a high temperature cooler or directly from a multiple effect receiver. This multiple effect enables the compressor to fill up with much more weight of the refrigerant, and the resultant effect is a considerable increase in the compressor capacity.

A multiple effect compressor in use today, which gives excellent service, is constructed on essentially the same cylinder design as the uniflow steam engine which utilizes a piston of a length approximately that of the stroke of the machine. At the end of the travel in each direction, this piston uncovers ports or holes drilled in the cylinder liner, thus admitting the multiple effect gas. Various advantages have been claimed for multiple effect, principally that of power saving and increased efficiency but the main advantage of multiple effect operation as against that of double suction operation is not as widely stressed. It should be evident that a compressor which utilizes the same suction pressures on each side of the piston will have a very even power requirement inasmuch as the total pressures on the piston will approximately balance. These pressures would be identical were it not for the fact that allowance must be made for the area of the piston rod. When, however, we operate in a double acting ammonia compressor on the double suction principle, with one suction pressure in one side of the cylinder and another suction pressure in the other side of the cylinder, we have mean effective pressures on the piston of widely different values instead of approximately the same values as those obtained from a case of single suction operation. This unbalanced effect, of course, requires additional flywheel effect to balance the machine properly and cause a more even power pull. Such flywheel effect may be added in the form of a flywheel properly designed or in the rotor of the motor driving the compressor should the unit be direct connected.

With the multiple effect compressor, however, such additional flywheel effect is not required. A close investigation of the principles covering multiple effect compression would explain this condition to us and we can more easily understand the entire cycle by putting ourselves in the place of the ammonia gas in the refrigerating system. As has been said, the multiple effect compressor is identical with the simple compressor except for the fact that there are ports located in the center of the cylinder which are uncovered by the

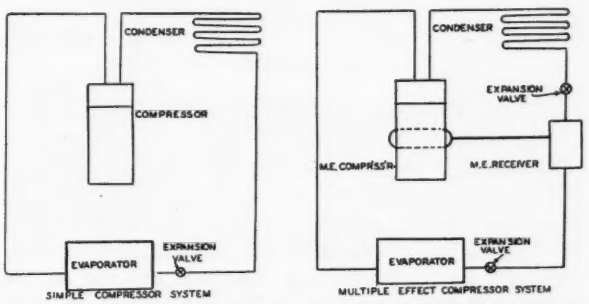


FIG. 1. COMPARISON OF THE SINGLE AND MULTIPLE EFFECT COMPRESSOR SYSTEMS

piston at the end of its stroke. These ports are seldom larger than ½ or ¾ in. in diameter and, of course, tend to reduce the total displacement of the compressor by just the percentage of the uncovered multiple effect port to the length of stroke. In other words, if we have a 20-in. stroke machine with ½-in. multiple effect ports and these ports are fully uncovered at each stroke of the piston, our effective capacity of the low suction side of the compressor will be reduced 1/40 or 2½ per cent, a negligible quantity when compared with the advantages gained in the use of multiple effect operation.

Let us now put ourselves in a convenient location inside the ammonia compressor cylinder and observe what takes place during a complete cycle of operation. We will say that the piston is at the end of its discharge travel, that it has passed its dead point and has begun the suction stroke. As there is a certain amount of clearance in the compressor cylinder, the first operation that must be performed is called re-expansion or the lowering of the pressure inside the cylinder from discharge pressure to suction pressure. In multiple effect operation, the lower suction pressure is connected in the usual manner to the regular suction valve while the multiple effect or high suction pressure is connected to the multiple effect ports.

When the piston has traveled far enough, point B on the indicator card, Fig. 2, sketched herewith, the further travel of the piston causes a pressure in the cylinder lower than that of the low suction pressure

*Formerly with the Vilter Manufacturing Co.

and permits the low suction gas to enter the suction valves in the usual manner. This operation continues until the piston uncovers the multiple effect ports at point C where the multiple effect pressure gas, being at a higher pressure than the low suction gas, rushes in through the multiple effect ports and causes the low suction gas valves to close.

There has been some discussion as to the length of time which the multiple effect ports remain open and as to whether there will be sufficient time for the gas to enter the cylinder and bring it up to a pressure approximately that of the multiple effect pressure. In Fig. 3 is shown a sample indicator card drawn directly

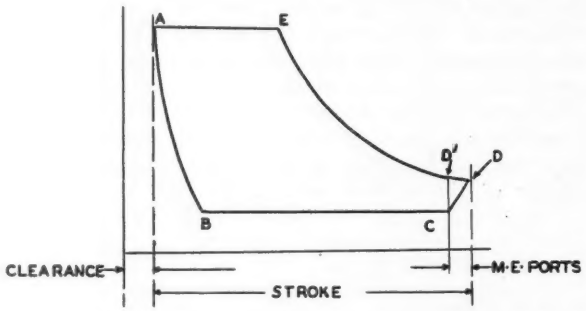


FIG. 2. INDICATOR DIAGRAM OF MULTIPLE EFFECT COMPRESSOR

above a circle which represents the travel of the main pin on the crank shaft. By dropping perpendiculars from the indicator card to the circle, we can determine position of the crankpin at any time during its rotation and the corresponding condition existing in the cylinder at that time. Since the multiple effect ports are ½ in. diameter and the stroke of our machine is 20 in., we can lay out this ½ in. as 1/40 of the total stroke of the compressor and drop a perpendicular to the crankpin circle. The points at which this perpendicular cut the crankpin circle show the points at which the multiple effect ports are uncovered and covered. We may then draw radii from the center of the circle to these points and determine the angle included between such radii. In this particular instance, we find that the multiple effect ports remain open about 37 deg. of the rotation of the compressor. If the compressor is operating at 120 r.p.m., two revolutions will be completed in each second. We can then determine the length of time during which the suction valves are open and the multiple effect ports are open and we will see that there is ample opportunity for the multiple effect gas to enter the compressor cylinder.

Our next question is how much multiple effect gas will enter the cylinder under these conditions. It is very easy to determine the amount of low suction gas which the compressor will handle. Merely take the displacement of the compressor, multiply by the volumetric efficiency and again by the correction factor due to the multiple effect ports. This last factor may generally be taken as 0.975 inasmuch as the multiple effect ports in standard practice usually reduce the effective stroke 2½ per cent. This having been done, we can determine the number of pounds of gas existing in the cylinder. Do not neglect to add the gas remaining in the clearance space when determining the total weight of gas in the cylinder at the moment of the opening of the multiple effect ports. If the clearance is 2 per cent, the total weight of gas in the cylinder at the opening of the multiple effect ports is the equivalent displacement in pounds times correction factor plus the equivalent displacement in pounds times clearance. In other words, if our total equivalent displacement in pounds per revolution is 100, our correction factor 0.975, our clearance 2 per cent, the total weight of gas in the cylinder at the opening of the multiple effect ports will be $(100 \times 0.975) + (100 \times 0.02)$ or 99.5 lb. Knowing the pressure existing in the cylinder at the time of opening of the multiple effect ports and knowing the total volume including clearance of the cylinder at this point, we can determine the number of pounds of gas present.

Now the multiple effect ports are open and the gas at higher pressure rushes in. We can closely determine the weight of gas to enter through the multiple effect ports by following the procedure outlined herewith. By referring to a Mollier diagram for ammonia, we can find the point on the diagram which corresponds to the condition of the suction gas. When the multiple effect gas rushes in the cylinder, we may consider momentarily that it acts as a piston and compresses the gas already in the cylinder to the multiple effect pressure. This compression is accompanied by an increase of heat which we may understand on the Mollier diagram by following the adiabatic compression line upwards and to the right until we reach the multiple effect pressure. The specific volume of the gas at this condition is considerably less than at the lower pressure, therefore

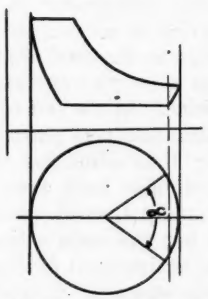


FIG. 3. INDICATOR CARD REFERRED TO CRANK ROTATION

the same weight of gas already in the cylinder requires much less space. We might say that the volume of gas to enter the cylinder could be determined by subtracting the total volume of the low suction gas in the cylinder at the high suction pressure from the total volume of the cylinder available. This, however, would be incorrect inasmuch as the multiple effect suction gas entering the cylinder is cold in comparison with the compressed low suction gas. By cut and try method, we can arrive at the proper condition of the mixture of low suction and multiple effect gas in the cylinder at the closing of the multiple effect ports. Such procedure is exceedingly laborious, however, and for all normal purposes, we may say that the condition of the mixture of low suction and multiple effect suction gas at the closing of the multiple effect ports is the mean of the values of the compressed low suction gas and the entering multiple effect gas.

By taking the specific volume at this point, multiplying this factor by the weight of gas in the cylinder

at the opening of the multiple effect ports and subtracting the volume thus obtained from the total volume of the cylinder available at the opening or closing of the ports, we may determine the volume available for multiple effect gas. We cannot figure on this entire volume in our calculations, since such effects as wire drawing, orifice factors, inertia, etc., reduce the available volume to about 90 or 95 per cent of its original value. For slow speed machines, 95 per cent is quite safe whereas with high speed machines, 90 per cent is a better factor. The remainder of the cycle is simple indeed, being the usual compression and discharge phases.

NOTE: This is the first of two articles on this subject. A second will appear in an early issue.

Control of Water Flow Through Filters

BY C. C. HERMANN

UNIFORM FLOW of water is highly desirable in either the gravity or pressure type filters. To allow the rate of flow to exceed a predetermined velocity means that some raw or partially raw water will be

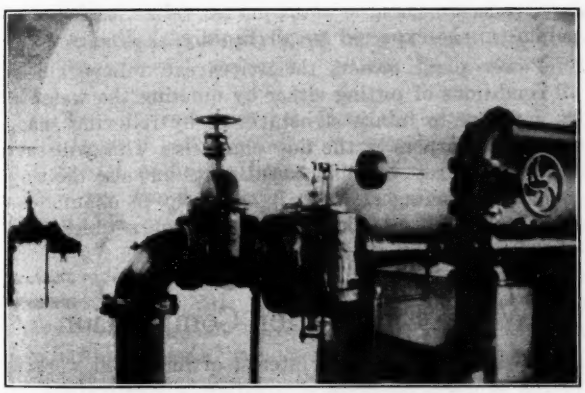


FIG. 1. INSTALLATION OF FLOW REGULATOR

sent into the mains. When the filter bed is comparatively clean, the resistance to flow within the bed is much lower than when the coagulated deposit has accumulated therein. Without some means to control the flow, the impurities of the water will be carried deeper into the filter bed, due to the higher velocity of the water while the bed is clean and there is every possibility that much of the impurities will be carried over into the mains.

Changes in the rate of flow from the filter, or to it in the event the gravity system is in use, must be avoided so far as practicable or at least such changes must be gradual. The rate, however, must not exceed at any time the maximum predetermined rate of the filter. Figure 1 illustrates an installation of a rate of flow controller at the plant of the Davenport Water Works. Pressure type filters are used comprising 12 tanks 8 ft. in diameter and 32 ft. long. Each filter is provided with 700 strainers and filled with five grades of rock and gravel ranging in size of rocks from approximately 2 in. in diameter down to a fine gravel.

Water is admitted to the filters at the top under a pressure of 70 lb. per sq. in. The rate of flow controller is located at the outlet of the filter and comprises a venturi tube with the discharge flange connected to a valve body. This is more clearly shown in Fig. 2, which is a cross section of the Simplex controller. The valve body contains a double disc-type balanced valve, the valve stem of which engages a diaphragm near the bottom end and a flexible connection to a lever arm at the top. The chamber below the diaphragm within the valve body is in communication with the venturi throat by a hollow tube.

The action of the venturi is the same as the ordinary venturi, a difference in pressure being developed between the water within the valve body and that in the venturi throat, due to the difference in the velocities at these points. The downward pressure on the top of the diaphragm is greater than the upward pressure, causing a downward pull on the valve which is balanced by the weight on the lever arm. Obviously the balance of the

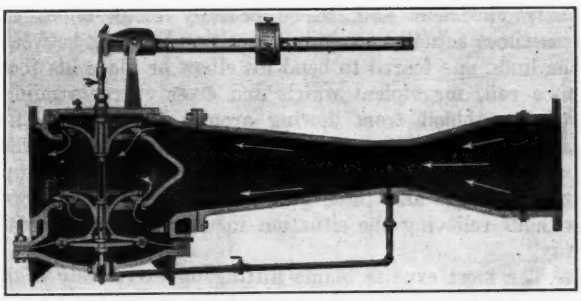


FIG. 2. CROSS SECTION OF VENTURI TYPE FLOW REGULATOR

counterweighted arm and the diaphragm load limits the rate of discharge by the valve and altering the positon of the weight varies the flow. This provides a simple adjustment for any rate of flow since it is possible to calibrate the lever arm giving the position of the counterweight for any desired flow within the capacity of the device.

Absence of working parts, excepting the valve stem and discs, makes this type of flow controller practical and long lived. Where desired recording instruments may be secured in connection with the controller and a permanent continuous record obtained of its function. Such a recording instrument may be placed at any advantageous position and at a considerable distance from the controller.

POWER HOUSE CRANES, a report of the N. E. L. A. Hydraulic Power Committee, Engineering National Section, has just been issued as publication No. 01 from headquarters of National Electric Light Association, 420 Lexington Ave., New York. Requirements and type of construction acceptable for cranes used in power houses and substations are outlined, based on information on crane design obtained from member companies and crane manufacturers. Construction is recommended which it is believed will be satisfactory for the services given and which should permit economies in construction with due regard for safety.

METERING of city water supplies is almost universal.

A Little Essay About Bunk

Including a Few Words on Pitting of Hydraulic Turbines. By A. de Bunker

EVERY LINE of effort imaginable, from Abattoirs to Zoning Experts, seems to include the priceless ingredient of bunk. Between those extremes of the dictionary, therefore, you would expect to find the water power business, which proves to be the case.

Thanks to the inherent good sense of the technical world, assisted in no small degree by experience and retrospection, the water power business is on the way to a complete cure from a bad attack of "draft-tube-itis," which came near leaving permanent scars. Think of it, dear reader! Young and helpless college boys were exposed to lectures and reams of writing all describing the many million revolutions made by a whirling column of water leaving a water turbine runner and about to go through an appended draft tube and mercilessly exposing the dear old elbow draft tube as sadly inefficient and, to be brutally frank about it, sometimes actually a minus quantity. Reading between the lines, one feared to bend his elbow or place his foot on a rail, for violent whirls and cross currents might stop the blood from flowing around the bend. The latest hooey has been pitting. The publicity given this pregnant subject has filled many of us old timers up to our gorges and these gorges cannot fill much more without relieving the situation in a broad and general way.

The most erudite blame pitting on excessively high draft heads such that the total of the static draft head plus the meridional velocity head at the runner throat may be anything from 28 up to 33.9 ft. head of water; in other words, almost perfect vacuum existing at and near the discharge edges of the runner vanes. Then rapid chemical action can be expected and any metal near such activity can be counted on to have a comparatively short life. And there are other theories, with details and details ad nauseam.

Is it Fair to Blame Pitting on the Turbine?

Often the entire blame for pitting is placed on the turbine itself. This is bunk, to say the least, and what is more it is bunk in an aggravated and costly form. I well recall a number of cases that are now almost 20 yr. old. Two medium speed turbines were built to run under a head of 75 ft., using the same runner pattern. They were installed some 30 mi. apart, the draft head being about 10 ft. One runner pitted badly, the other did not. The water contained nothing harmful and, taken bye and large, I seldom recall two settings as near duplicates. One runner had to be renewed every year while the other ran for ten years and then the vanes are not worn through.

Another case might be mentioned in which the draft head is somewhat over 32 ft. Slight pitting has been noticed and the life of the runners has been from seven to eight years. Another baffling case was a comparatively low head plant consisting of horizontal shaft units with four runners per unit. The draft head, counting both static and velocity heads, was not in excess of 20 ft., and among several such units but one runner on the extreme end pitted very badly. All the others had lives that one would call normal; that is, from eight to ten years. They were comparatively slow speed runners, reckoning speeds as we do today.

In each of the above cases, the primary cause was isolated, and when that was done, the pitting stopped and the trouble was cured. When, at the entrance to a pipeline, there are sudden and sharp turns that cause eddies and whirls or small vortices to be formed so that air is entrained, this air is carried down the pipeline and into the turbine and, of course, is released where the pressure is lowest, where the chemical action goes on. In each case where a stilling basin was made at the entrance to a pipeline or the sudden and sharp turns removed, the pitting stopped in the cases noted. In the case of the horizontal shaft units above cited where the end runner pitted, the approach of water toward a pier was angular so that the water whirled around a pier nose and a lot of air was entrained. After a plate steel deflector had been made to correct that whirl, the pitting stopped.

Many other cases could be cited which would merely take up valuable space here. To blame the turbines for pitting is as full of bunk as it would be for a doctor to say that the patient ate a horse because a saddle was seen under his bed.

Not only does water behave like this, but so does oil, and to a marked extent. Where there are sudden and large velocity changes, as at needle valves, nickel steel points can be expected to pit rapidly.

Power plant owners themselves can relieve almost all conditions of pitting either by quieting the water at its entrance to intake structures or by relieving sharp turns and corners in the flow channels. This will save not only the cost of replacement parts but also the time and cost of outages. Also it will help to eliminate a large part of the bunk now going on, over which most of us are barking up the wrong tree.

Waste Elimination Competition

In order to stimulate interest of industrial workers in the problem of waste elimination, a competition for the best suggestion or idea for Waste Elimination advanced by an employe, is announced by George E. Pfisterer, director of the National Industrial Equipment Exposition. A cash award of $50 will be given to the employe submitting the best suggestion on the subject and a certificate to the plant where he is employed. Suggestions must be in the hands of the award committee by midnight of May 30, all suggestions to be mailed to the National Industrial Equipment Exposition, 308 West Washington Street, Chicago, Ill. Basis of the award will be on the practical use of the suggestion to American industry and the quality of the suggestion.

Any company is eligible to send in three suggestions from employes for consideration, the suggestions being covered in an article of not more than 300 words. The committee to decide the winner consists of James D. Cunningham, past president of the Illinois Manufacturers Association, John Carmody, president of the Society of Industrial Engineers, and O. G. Auel, chairman of the committee of waste elimination of the A.S.M.E.

Feedwater Regulator Drains

USUALLY, the large power plant boiler is amply protected against feedwater regulator troubles induced by depositing scale. In the first place, large boiler installations are equipped with complete water conditioning apparatus that makes scale deposits in the feed system rather rare. Second, the feedwater is usually heated beyond its scale deposition point, somewhere between 150 and 200 deg. F., by heat exchangers or regular feedwater heaters utilizing waste steam. Third, the types of regulators used are not subject to scale deposits, since the regulator is generally some form of expanding tube with an external connection to the feedwater valve itself.

When, however, you get down to the multitude of small isolated boilers ranging from 1 to 15 hp., often gas fired, conditions become quite different. Such boilers are found in large numbers in all active communities in smaller establishments, or in special departments of large plants. There a float type of feedwater regulator is universal with raw cold make-up water and with little attention to maintenance, since these boilers are considered automatic. The writer in his locality, where very hard water is encountered, found that after a few months' use many of these feedwater regulators are rendered inoperative, mostly from these causes:

1. Raw cold water entering the float chamber and being heated to above scale-depositing temperature.
2. Scale deposits on the valve seats, causing the boiler to flood continually.
3. Scale fills water leg of float chamber, isolating it from the boiler, so that the float may shut the water off and the boiler may run dry.
4. Scale deposits in the float chamber proper which may cause either flooding or feed failure, depending on how the float sticks.

Installation of feedwater heaters, particularly of the deaerating type for the prevention of corrosion, is out of the question on most of these boilers and even water softeners are often shunned. In such cases, a simple change in the piping will render the feedwater regulator effective over long periods, if occasional attention is given to drainage and flushing.

Figure 1 shows the normal method of piping the regulators, without flushing or cleanout arrangements. Figure 2 presents the suggested piping with provision for draining, flushing and cleaning, without breaking unions or shutting down the boiler for removal of plugs; in fact, without doing much at all.

A glance at Fig. 1 shows that the only possible way to clean out the feedwater system is to shut down the boiler, break the unions (4) and remove the apparatus. Of course, in case of dirt on the seat of the float valve,

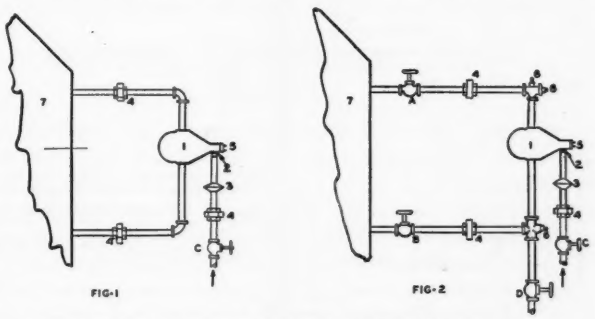


FIG-1
FIG-2
1-FLOAT CHAMBER 2-AUTOMATIC VALVE SEAT- 3-COLD WATER STRAINER-
4-UNIONS FOR REMOVAL OF FLOAT CHAMBER - 5-VALVE CLEANOUT PLATE-
6-CLEANOUT PLUGS IN CROSS- 7-PART OF BOILER SHOWN- A & B-STEAM &
WATER LEG VALVE- C-COLD WATER INLET VALVE- D-SYSTEM DRAIN VALVE-

FIG. 1. USUAL PIPING FOR FLOAT CHAMBER
FIG. 2. PIPING ARRANGED FOR EASY CLEANING OF FLOAT CHAMBER

the plate (5) can be removed, when the boiler is shut down and the seat somewhat cleaned.

With the arrangement of Fig. 2, however, the system can be thoroughly flushed or blown down, and even the entire float chamber can be removed without shutting down the boiler. The method of cleaning would be as follows:

1. Float chamber: Close valves B and C, and open drain valve D, permitting the water from the float chamber to blow until steam from the boiler, through valve A, appears.
2. Water leg: Close valves A and C, and open drain valve D, permitting water from the boiler to blow out of the drain.
3. To flush float chamber: Blow down float chamber as described in 1. Then close the steam valve A, leaving only valve D open and open fresh water valve C, allowing water to drain out through valve D.
4. For plugged lines: Should any of these lines be plugged solid, with valves A and B closed, thus isolating the float chamber system from the boiler, the cleanout plugs 6 can be removed and a rod pushed through in any direction, using the drain and valve D for a rod going up into the float chamber proper. Should the

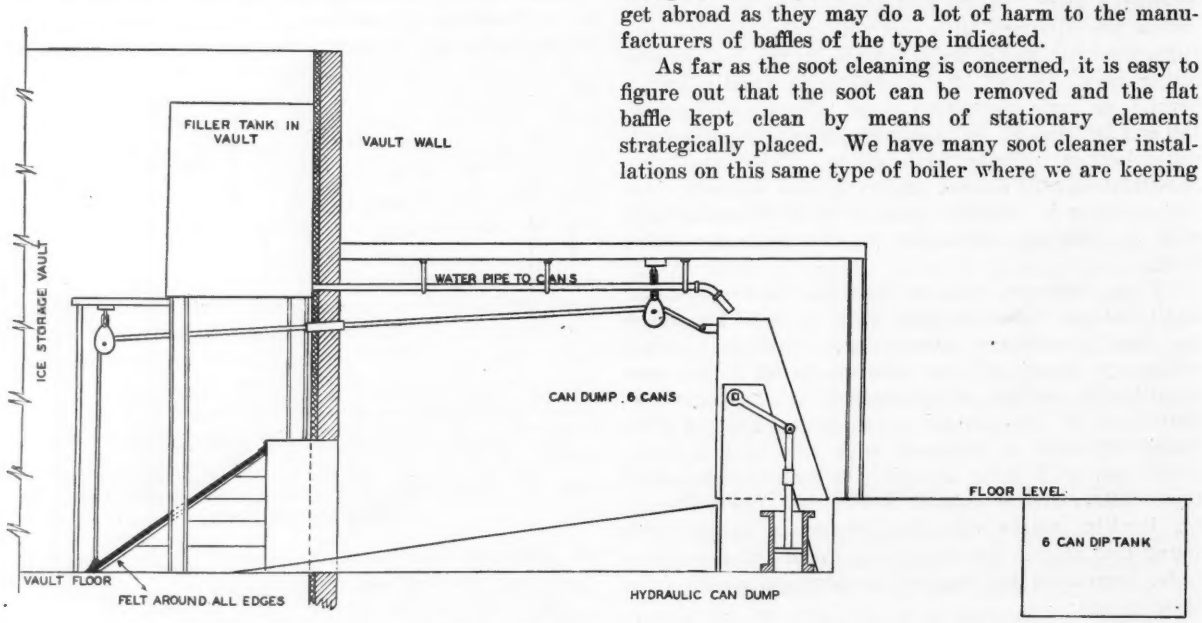
boiler lines be plugged, that is, between the valves A or B and the boiler, these valves can be opened and the rod pushed through to the boiler, care being taken to avoid the hot steam or water from blowing upon the operator. Immediately connection has been made and steam or water blows, valve A or B can be closed and all plugs replaced.

All valves should be gate valves. Where the condition of the feedwater requires it, this operation should be thoroughly applied regularly each week, as only a few minutes are necessary for the complete blowdown.

Dayton, O. C. W. STEVENS.

Automatic Door Lift for Ice Chute

WHEN I WAS transferred by my company to this plant, three of the six chute doors were out and sacks hanging over the openings although the plant had been in operation less than two years.



SIMPLE CABLE ATTACHMENT MAKES OPENING OF ICE CHUTE DOOR AUTOMATIC

At an expense for material of only $6.40 and with the aid of parts picked up from scrap, the arrangement shown in the illustration was constructed. We have had no repair expense since and no changes were necessary in the present chute. The necessary changes to the door were minor ones. I made a door to cover the six openings and set it on an angle as shown. The ends were then walled up and a $\frac{5}{16}$-in. cable attached to the door, passing this cable through a hole in the wall and over two pulleys to the can dump.

Six cans are dumped at a time and, as the dump is lowered, it causes the door to be raised automatically. As the dump rights itself, the door closes of its own weight. Application of this method may be made to any ice-dumping arrangement regardless of the number of cans dumped at a time or the method of operating the dump itself.

Robstown, Texas. J. W. SMITH.

Horizontal Boiler Baffles

ON PAGE 195 of the February 1 issue is a short article written by W. F. Schaphorst entitled Avoid Horizontal Boiler Baffles, in which it is stated that when baffles are sufficiently flat to permit soot and ash to lodge upon them, this deposit will not be blown off by steam through soot blower nozzles.

This statement is entirely too broad to be correct. When soot blowers are installed in the proper locations to effect thorough cleaning with baffles of the type referred to, there is no difficulty in removing soot and ash accumulations. We have made a great number of successful installations on boilers baffled in this way.

Detroit, Mich. GEORGE L. DAVIS.
Asst. Sales Mgr., Diamond Power Specialty Corp.

ON READING Mr. Schaphorst's article on page 195 of the February 1 issue on the subject of Horizontal Baffles, I was at first inclined to pass it up. On second thought, however, it is best not to let ideas of this kind get abroad as they may do a lot of harm to the manufacturers of baffles of the type indicated.

As far as the soot cleaning is concerned, it is easy to figure out that the soot can be removed and the flat baffle kept clean by means of stationary elements strategically placed. We have many soot cleaner installations on this same type of boiler where we are keeping the flat baffle free from soot. What may have happened is that a soot cleaner installation was not properly designed, so the whole arrangement is condemned on one or two observations.

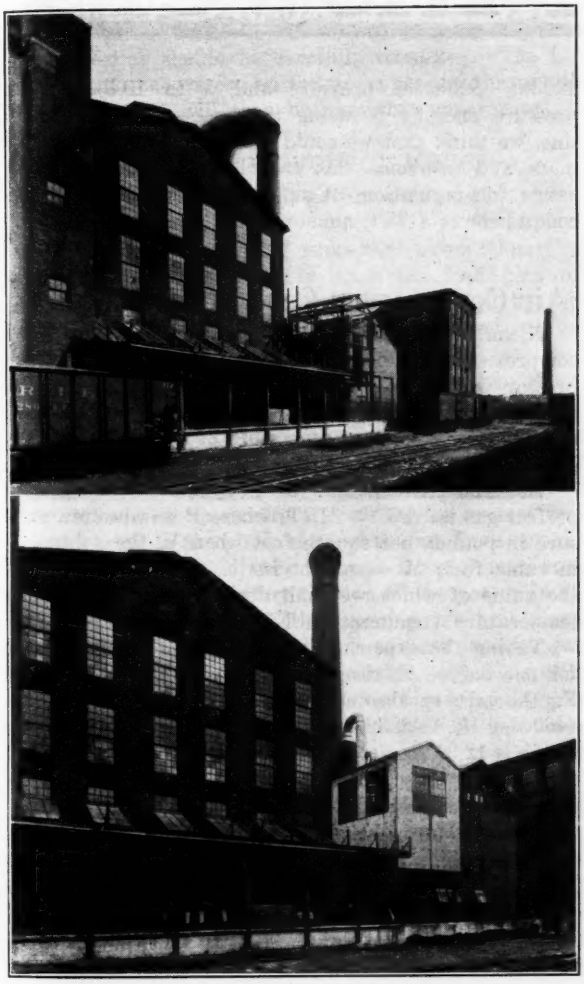
Du Bois, Pa. WM. C. IHDE,
General Sales Mgr., Vulcan Soot Cleaner Co.

IT IS STATED in the article on page 195 of your February 1 issue, Avoid Horizontal Boiler Baffles, that soot and ash will not be blown off of the baffles, if boilers are baffled in the manner illustrated. This statement is erroneous, as we have plenty of installations of this character equipped with Bayer soot blowers and the boilers and baffles are being kept entirely free from soot and ash deposits.

THE BAYER COMPANY,
St. Louis, Mo. LEO JNO. BAYER, PRESIDENT.

Standardization of Dust Recovery Performance

PERFORMANCE comparison of dust recovery of fly ash from pulverized fuel burning installations such as were described on page 112 of the Jan. 15 issue, should be on a common basis of operation guarantee.



COMPARATIVE STACK CONDITION DURING SOOT BLOWING OPERATION, BEFORE AND AFTER INSTALLATION OF DUST FILTER

One company makes the following statement of expected performance:

Retained on	50-mesh	screen	.....	99	per	cent
"	"	100	"	"	.....	98	"	"
"	"	200	"	"	.....	96	"	"
"	"	300	"	"	.....	93	"	"
Finer particles	.....	Large proportion					

This form of performance guarantee seems to be in the proper direction but, to one familiar with fly ash, it is not carried far enough to form any real basis of comparison. The following screen test of fly ash recovered by The Dust Recovering & Conveying Co.'s equipment at the plant of the Acheson Harden Co. at Passaic, New Jersey, which was described in the June 15, 1928 issue, will indicate what has to be dealt with as far as fineness is concerned:

SCREEN TEST OF AVERAGE SAMPLE OF ASH RECOVERED FROM FILTER UNITS

Plus 65-mesh	screen	.....	0	per	cent
" 100	"	"	.....	0.25	"	"
" 150	"	"	.....	0.76	"	"
" 200	"	"	.....	2.02	"	"
" 300	"	"	.....	3.22	"	"
Minus 300-mesh	screen	.....	92.7	"	"
Total	.....	98.95	"	"

In other words, the performance guarantee, mentioned above, is specific for a little over 6 per cent of the recovery, while 93 per cent is covered only in vague terms. Photographs taken of our plant during soot blowing, before and after the filters were functioning, give a good visual record of the collecting efficiency of the filter equipment. The screen test shows clearly how fine the bulk of the recovered ash is.

Passaic, N. J. CHARLES D. OWEN,
Plant Eng., The Acheson Harden Co.

Improper Boiler Setting Causes Foaming

TROUBLE with foaming described by Mr. Rutledge on page 143 of the Jan. 15 issue was caused, I believe, by the bridgewall shown in his Fig. 1. This bridgewall caused the flame to be directed against the boiler at a localized point, causing a false water level to be formed.

Building the bridgewall up to the boiler and putting the burner at the bridgewall may have cured his trouble but he has lost one-third of the heating surface of the boiler shell. To burn oil properly, as nearly perfect combustion as possible is required and this cannot be accomplished in a restricted combustion space. If the grates and bridgewall had been removed entirely so as to provide an unobstructed sweep from front to back wall, surprising results would have been obtained. The burner should be located at the top of the ashpit door, not less than 40 in. from the boiler shell; 48 in. would be better. Checkered brickwork aids combustion.

For 9 yr., I have been burning oil in my plant without the least trouble. No tubes have been burned out, no fire cracks have occurred in girth seams and no trouble has occurred with the brick walls during that period except for occasional renewal of brick walls when the boilers are forced unduly. I have 72-in. by 18-ft. h.r.t. boilers operating, at times, at from 200 to 300 per cent rating without causing trouble. They were designed for 150 hp. capacity but it is not unusual for me to get 250 or 300 hp. from them.

Best operating results are obtained by heating the oil to 250 deg. F. and using steam at 120 lb. pressure for atomization. With a draft of 0.015 in. of water, I obtain 14 per cent of CO_2. I use needle valves on the steam and oil lines and the oil used is of 12-deg. Baumé gravity.

New Bedford, Mass. S. E. CUNNINGHAM.

INSTRUMENTS are of little value unless intelligent use is made of the data obtained from them.

Comments on Improving Refrigeration Regulation by Suction Trap

THE ANSWER to the question of A. A. A. in the June 1, 1929, issue, having to do with the matter of regulating liquid valves, commonly called expansion valves, is good but I believe that a further consideration of the problem is necessary before a satisfactory solution is possible.

To begin with, there is something radically wrong when the condensing pressure varies from 150 to 260 lb. Either there is insufficient water supply, the system is full of non-condensable gases or, perhaps, an insufficient number of condensers are installed. In any event, this is an abnormal condition and one that is wasteful of power.

It would be interesting to know how many lineal feet of pipe are connected to each of the 23 expansion valves in use and whether or not the coils are free from oil and are defrosted regularly. Three things can cause liquid to escape from the coils before evaporation: Coils heavily coated with oil on the inside, causing retardation of the rate of evaporation; heavy deposits of frost on the outside, which have the same effect, and coils that are too short and therefore contain only a relatively small amount of surface, allowing liquid to pass to the suction header because the time that the ammonia is exposed to the heat which produces evaporation is too short. In other words, the time given for the ammonia to pass through the coils is so short that, unless there is a very considerable temperature difference between the ammonia and surrounding air or brine, complete evaporation of the liquid to a saturated gas will not occur.

Disadvantages of short coils are multiplied by the presence of a heavy coat of frost on the outside or deposit of oil on the inside. The liquid trap or accumulator which is described is excellent but, in the writer's judgment, it will pay to investigate the points mentioned to see whether or not the source of the trouble can be found.

Atlanta, Ga. C. T. BAKER.

Editor's note: As it has been impossible for us to get the information requested by Mr. Baker, comments are printed and we are repeating the original question put by A. A. A.

"We have 23 expansion valves in our refrigeration plant, which have to be so nearly closed to be regulated that our margin of range is insufficient, thereby requiring considerable attention.

"We have been thinking that, if we installed a master or regulating valve on the liquid line between the receiver and the expansion valves near the freezers, it would overcome this trouble. We run from 150 to 260-lb. condenser pressure and 5 to 10-lb. suction pressure and, by reducing the pressure in the liquid line, we think that we could open our expansion valves more and overcome this trouble by making a wider range for regulation. Our liquid line is 1¼-in.; our compressor is a 75-t. ammonia machine."

A. A. A.

Air Compressor Capacity Calculation

KINDLY LET ME know how to calculate the volume of compressed air delivered per minute by an air compressor which takes in 154 cu. ft. per min. of air at atmospheric pressure and at a temperature of 70 deg. F. and delivers this air at a pressure of 95.3 lb. per sq. in. gage and at a temperature of 150 deg. F. A. H.

A. The fundamental thermodynamic equation of a perfect gas is: $PV = MRT$, where P = absolute pressure in pounds per square foot when V, the volume, is in cubic feet; M = weight in lb.; R = gas constant, the value of which we shall derive and T = absolute temperature (temperature F. plus 460).

Taking the expansion of air as 1/492 of its volume for one degree F. rise of temperature from 32 degrees F., the zero of absolute temperature = 32 — 492 = –460 deg. F. At 32 deg. F., the volume of one pound of air is 12.39 cu. ft. at 14.7 lb. per sq. in. press., therefore solving for R by means of the thermodynamic equation given above, we have:

$PV = MRT = 14.7 \times 144 \times 12.39 = 1 \times R \times 492$, whence $R = (14.7 \times 144 \times 12.39) \div 492 = 53.3$ for air. Therefore $PV = 53.3\ MT$.

For the original condition, $P_1 V_1 = M_1 R_1 T_1$ and the final condition, $P_2 V_2 = M_2 R_2 T_2$.

Since a constant weight of air is considered, $M_1 = M_2$ and $R_1 = R_2$.

We can now equate $P_1 V_1 \div T_1 = P_2 V_2 \div T_2$.

From data given in your inquiry:

$V_1 = 154$, $P_1 = 14.7 \times 144$, $T_1 = 70 + 460 = 530$ deg. abs.

$P_2 = 95.3$ gage or 110 lb. abs. $\times 144$, $T_2 = 150$ plus $460 = 610$ deg. abs.

$(154 \times 14.7 \times 144) \div 530 = (V_2 \times 110 \times 144) \div 610$.

Solving: $V_2 = 23.70$ cu. ft. which is the volume of air delivered.

Superheat Supplied by Reducing Valve

WE HAVE a 32-in. dia. by 10 ft. long ironing machine in our laundry, which uses steam at 100 lb. press. and we are having trouble with condensation in the line. We also experience a lack of sufficient control in the mandrel to iron the clothes completely in one operation. Is it necessary to install a superheater in order to over-

come our trouble and if so, where can a suitable superheater be obtained? W. H. P.

A. We think it is unnecessary to install a superheater in your case unless the amount of condensation is great. If you install first, a drip pocket drained by a steam trap, and then a reducing valve, close to the mandrel, then use steam at about 80 lb. pressure in the mandrel, reducing it through the reducing valve, we believe you will overcome your trouble and irregularity of heating of the mandrel will be avoided. In any case, the pipe line should be carefully insulated. The trap will remove the water and the steam passing through the reducing valve will then be somewhat superheated.

Fly Ball Governor Races

WHAT CAUSES a fly-ball governor to race? L. N.

A. Several things may make the engine "hunt" or "race" for several seconds when the load goes off. Excessive friction of the cutoff device caused by accidental strain of some of the rods or connections will tend to retard the governing action of the governor. These parts must be absolutely free from strain of any kind.

On most governors as used on Corliss engines, there is a gagpot or a vessel in which a plunger works in oil to dampen the fluctuations and steady the speed. In connection with this there is some device by means of which the oil in the pot is allowed to pass from one side of the piston to the other through a small regulating valve which may be either outside of the pot or in the plunger itself. By trial, this opening can be set at a point where it will allow the oil to pass through just fast enough to secure good regulation. If this setting is varied either way, racing or hunting will be the result. As a general rule, a light machine oil is the best to use in the gagpot and sometimes it is necessary to add kerosene also in order to secure the best results.

The earlier governors for Corliss engines were of the fly-ball type without counterpoise and with lighter weight balls which depend on a high rotative speed to secure close regulation.

When the load is suddenly thrown off, this governor does not respond rapidly enough and the engine speeds up before the governor can control it. The excessive speed naturally increases the speed of the governor several revolutions, causing the extra centrifugal force which is set up to throw the fly-balls too far outward where they revolve in a new plane, in which position cutoff takes place too early and the engine slows down. This oscillation above and below normal speed goes on for several seconds until the engine again comes under control. It is entirely possible that the racing is caused by a combination of these causes.

Power Required for Ice Making

WILL YOU please tell me how many horsepower it requires to make 50 t. of ice daily with an ammonia condenser temperature of 75 deg.? F. D.

A. Where ammonia is the refrigerant, the horsepower required will depend on the pressure range between suction and discharge and the cubic feet of gas handled per minute but the mechanical characteristics of the compressor will affect the actual power needed.

Assuming a suction pressure of 30, we may obtain the indicated horsepower for the compressor cylinder by use of the chart illustrated. The pressure corresponding to a condenser temperature of 75 deg. is 127 lb. From a point on the left scale corresponding to 127, we move horizontally until we intersect the suction-pressure line marked 30. Now, dropping vertically to the bottom scale, we find the compressor horsepower per ton refrigeration to be 0.8, which is the indicated horsepower for the compressor per ton refrigeration. In order to obtain the actual driving horsepower required, this amount must be increased 30 per cent, or to 1.04 hp.

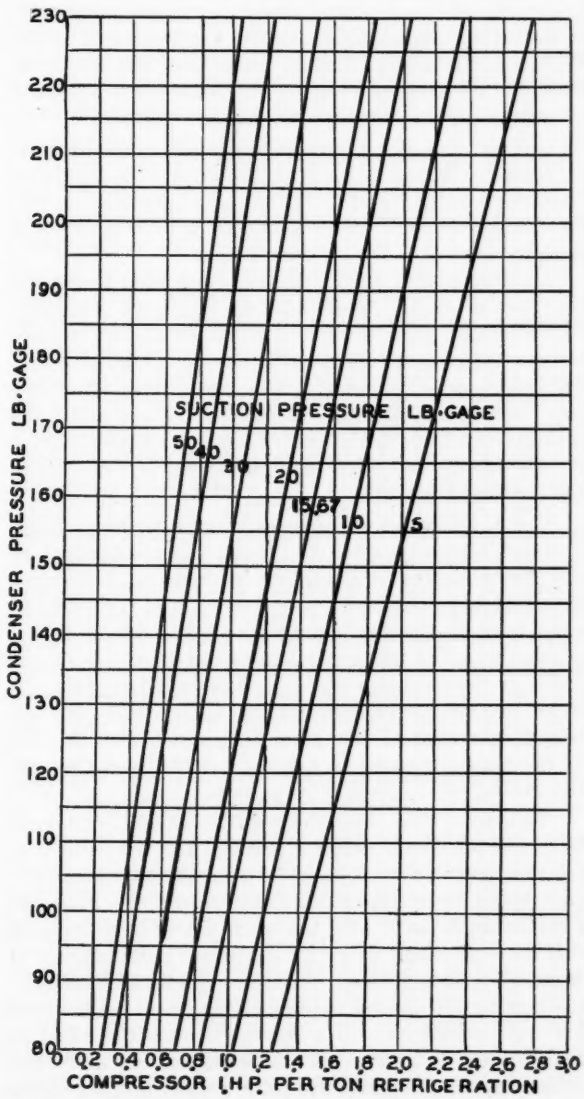


CHART SHOWING RELATIONS BETWEEN AMMONIA CONDENSER PRESSURE, SUCTION PRESSURE AND INDICATED HORSEPOWER

Power required per ton of ice is twice that per ton of refrigeration, hence $1.04 \times 2 = 2.08$ hp. per ton of ice will be required and, for 50 t., the total horsepower required will be $50 \times 2.08 = 104$.

In the chart shown, 15.67 is the gage pressure of saturated ammonia at zero degrees temperature.

Editorial Comment

Ironing Out the Kinks

Power plant design has progressed to the point where prediction of the heat required to produce a kilowatt-hour can be made within a few hundred heat units. When all the varying factors are considered, this is remarkably accurate calculation and indicates how closely to set standards power plants can be operated.

Seldom, however, does a power plant reach its peak of economy within a year of the time it is put into operation and, during this initial period, installed equipment is put through severe tests both as to efficiency and capacity.

In large plants, these tests are conducted under the supervision of the most skilled engineers available. Being trained in this work, these engineers are usually able to detect conditions which have a tendency to reduce efficiency or capacity. To correct these conditions may require a change in instructions to operators, the installation of additional control devices or instruments, a slight change in design or arrangement or a change in fuel or supplies used.

Due to the many variables entering into the problem, it is not always possible to predict the exact effect of changes in design or operating methods, so it becomes necessary to go through a period of cut and try until the very best results are obtained. This period, during which the kinks are being ironed out of the plant, is probably the most important in the life of the plant, for upon the results secured during this period will the future operation of the plant be judged, also the life of the plant depends, to a great extent, upon the care the machinery is given at this time.

To start a new plant in operation should, therefore, be looked upon as a research problem and the method of solution should be conducted in the same way a scientist goes about determining unknown relations. First, he familiarizes himself with the work others have done on this same problem, to avoid unnecessary duplication of work, then designs and procures equipment necessary for making the desired determinations, next he conducts his experiments in such a way as to note the effect of one variable at a time, all the while making notes and tabulating results which are later worked up into curves by means of which relationships can be studied and results compared.

In the power plant, each piece of equipment has a definite function to perform and it is the duty of the engineer to see that it is suited to the service. It is unnecessary to conduct tests on every detail of equipment of the plant but operating men should be instructed and trained to report every incident when a piece of equipment fails to function as it should or is found defective in any respect. Such incidents should be investigated to determine the causes of failure and repeated failure should invite thorough testing.

To aid in putting a plant in perfect operating condition, a complete system of records is essential, wherein the operating history of each piece of equipment is recorded; particularly all repairs should be recorded in detail as, too frequently, defects develop as a result of faulty repair work.

Research work, be it scientific or crude, is always done when starting a plant but it should continue as long as the plant is in service, since new methods of doing things and new types of equipment are always becoming available. Each plant should be kept continuously under study to see how it can be improved.

Industrial Plant Load Characteristics

Characteristics of the electrical load of various industries differ considerably with the character of the industry. In the textile, food, chemical, leather and kindred industries, where the load is more or less continuous, the installed motor horsepower exceeds the generating capacity by but a small margin.

Of fifteen industrial groups having an average ratio of 1.52 hp. of installed motors per horsepower of generating capacity the textile, chemicals, leather, printing, non-ferrous metals, food, lumber, transportation and paper industry, have ratios below 1.4. Stone, petroleum and coal machinery and railroad repair shops have ratios ranging between 1.4 and 1.75 while the iron and steel industry with a ratio of 2.14 is the highest.

This ratio, which approaches the diversity factor of the industry, is of value in laying out preliminary designs and problems, as it indicates in a general way the amount of generating or transformer capacity that will be needed to serve a given connected load.

Divisions between the industries are quite definite. Iron and steel, the largest power consumer with 1,688,703 kw. of generating capacity, has a factor of 2.14 while textiles, the next largest power consumer with 1,005,723 kw. of generating capacity has a factor of but 1.05.

Further Progress in Circuit Breaker Design

Like the poor, the circuit breaker problem we have always with us. Gradually, however, by constant study and by persistent research, the veil of mystery which has always obscured the solution of this problem is being lifted and in view of the recent disclosures of the Westinghouse Co., it seems that we are on the right track to a full solution. As is stated in an article in this issue describing these recent developments, it may seem strange that so simple a thing as the mere opening of an electrical circuit should present such difficulty and that, through all these years, while one complex problem after another has been solved and forgotten, the one of constructing a really effective circuit breaker should still remain with us. The reason, of course, is that behind the apparent simplicity of the opening of

an electrical circuit lies a complex phenomenon, which only the most pentrating insight into the theories of electricity and matter has been able to disclose.

One of the most astounding conclusions reached by the Westinghouse engineers is that the decomposition of oil by the heat of the arc in an oil circuit breaker, instead of being harmful and a thing to be avoided, is necessary and that it is the very decomposition of the oil that makes the oil breaker function. In other words, to improve the oil breaker, the rate of formation of gas through decomposition of oil, should be increased, not decreased. This explains the fact that liquids more volatile than the usual switch oil have been used quite successfully in certain types of fuses.

So, once again, exact knowledge scores over cut and try methods and faulty reasoning. It is too much to say that the new deion-grid oil circuit breaker will solve all our circuit breaker problems, but that the knowledge gained through its development will prove of unestimable value in the further progress of the art cannot be questioned.

Trouble or Emergency Lights

Power supply failure, although infrequent in modern power plants, does sometimes occur in spite of elaborate precautions taken to prevent it. When power is purchased, such interruptions cannot be avoided and in some sections of the country, where interconnection is not fully extended, the need for continuous service has led many industrials to construct and operate their own plants.

Regardless of the source of supply, however, interruptions and accidents will happen and the wide-awake engineer provides some source of illumination in essential locations; that is sufficient to enable the operators to get the equipment back into service.

Of course there are engineers who feel no necessity for such emergency measures until a major accident brings it forcibly to their attention. There are still others who feel no necessity for such provision even after it has been brought to their attention.

Recently, in an industrial plant purchasing power, a 24-hr. interruption of the power supply left the boiler room in total darkness without lights of any kind for a considerable period and with only candles for a period of five hours until an emergency current was run in. During the interim, candles were used, adding a fire and explosion hazard to an already dangerous situation.

Service was resumed at the end of 24 hr. but no attention was paid to the necessity for providing an emergency lighting circuit. Later, purchased power was abandoned and electric generators installed. Still no emergency lighting service was provided, even though the hazards were greatly increased.

Sudden failure of the power supply from any one of a number of causes such as exciter failure, tripping of a circuit breaker followed by the overspeed governor release or a severe short circuit, would plunge the plant in darkness, cause the safety valves to pop and make it practically impossible to resume operation again without a long delay.

A small turbine or engine-driven generator or storage battery serving a few carefully placed lights may be an expense which is hard to justify in a plant with a good record but at least a few lanterns ready for service and handily located are within the financial reach of all plants no matter how small.

Plant Housekeeping and Safety

In the whole category of causes of injuries, by far the most common are falls—a price the human race pays for the privilege of walking upright. It behooves the engineer, therefore, to study the condition of the floors, ladders, stairs, runways and other places where workmen must walk in the performance of their work. As a rule, the designs of these surfaces are in accordance with well established standards but too frequently carelessness manifests itself in littered floors and walkways partially obstructed by tools, repair parts and wheelbarrows not in actual use.

While it is customary to think of minor accidents or injuries as of little consequence, these injuries often become serious. In many cases, minor injuries result where severe injury would have occurred were it not for the agility of the victim in extricating himself from the situation. Hence study and correction of the causes which have brought about minor accidents or injuries will avert serious accidents.

In large measure, dangerous conditions are created by poor or careless housekeeping, indifference on the part of some to the stated rules of the plant and a shirking of individual responsibility for the order of things about the plant. With changing of seasons come variations in plant conditions and the need for periodic inspection of safety conditions. To those who have not already established this practice, the suggestion is made that the springtime is opportune to start a systematic safety program, as it is then that the construction and improvement work with its hazards unfamiliar to the plant force is usually started and the rapidly changing conditions around the plant emphasize in the minds of the plant attendants the need for safety precautions.

Hydraulic Power Development and Automatic Regulation

Automatic operation has been an important factor in the development of water power projects during the past few years. This is particularly true of the smaller sites which can be tied together into a single system. If labor charges of a normally operated plant had to be included, the developments might not be economical.

Control of equipment for high or low head plants differs little but this is not true for large and small stations. Operation of automatic plants may be carried on in a number of different ways as for instance: start and stop by variations of the water level; shut down by protective devices, such as high bearing or generator temperatures; started and stopped by overloads on other machines; light load for a given length of time; cut in when line frequency drops or push button or supervisory control from a remote point, perhaps a few yards or maybe many miles away.

Both synchronous and induction type generators are used in automatic stations. Synchronous generators are more widely used and are usually provided with damper windings so as to make them self-synchronizing unless the generator forms a large part of the system capacity. In that case, an automatic synchronizer is advisable.

Power Plant Engineering Developments and News

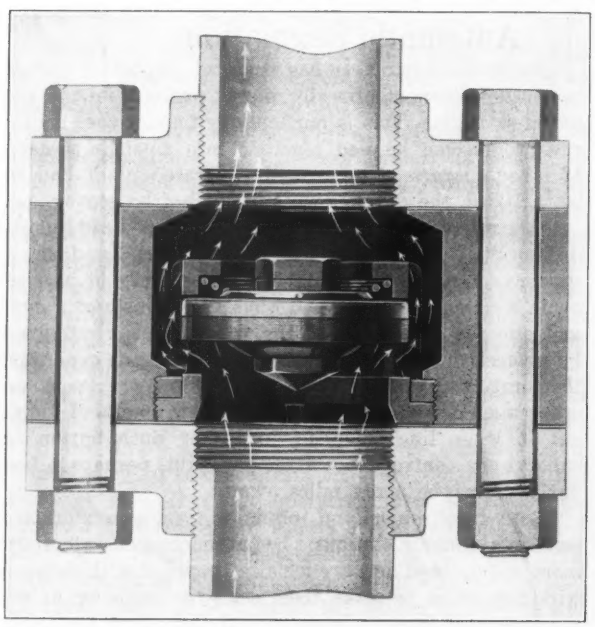
Hager Noiseless Check Valve

HAGER FLOATING CHECK valve, designed to operate noiselessly in any position, for pressures up to 500 lb. at 500 deg., has recently been developed. It is designed to give stream-line flow and to have all working parts easily renewable and removable. It is made to be clamped in place between two extra heavy flanges in the line and to occupy from 2½ to 4½ in. in the line for sizes from 1 to 6 in., which are stock sizes, larger ones being made to order. Built of metal to suit the service, it is intended for use in vacuum heating systems, boiler feed lines, house supply lines, air, oil gasoline and chemical lines. The manufacturer, The Williams Gauge Co., Valve Division, 343 So. Dearborn St., Chicago, Ill., and Pittsburgh, Pa., also recommends it for giving noiseless operation with centrifugal pumps.

The body of the check valve is of heavy cylindrical cast iron in the type 250 for pressures up to 250 lb., with government bronze trim and Wigaco disc. The body of the type 500 for 500 lb. pressure is of forged steel with nitralloy disc and seat, chrome nickel iron cage and special alloy spring.

Valve mechanism consists of a three-point guide cage that screws into the body, a self-cleaning valve disc with tapered holder to guide the flow, a renewable seat that screws into the body and a bee-hive spring to hold the valve disc to its seat.

The valve seat is screwed into the valve body until outer surfaces are flush; the fit and construction are such as to eliminate possible distortion of the body when the valve is heated. To prevent corrosion and erosion and to make the seat easily removable for refacing, a flange gasket extending to the inner circumference of the seat covers the threaded joint between body and seat. The disc assembly is built as shown with a lower tapered washer and a reënforced upper washer, the whole secured by a tapered-head bolt and locknut. This assembly guides the flow; the whole interior of the valve is designed to give free flow and to eliminate pockets.



CROSS-SECTION SHOWING CONSTRUCTION OF HAGER CHECK VALVE

Heat Exchanger Without Baffles

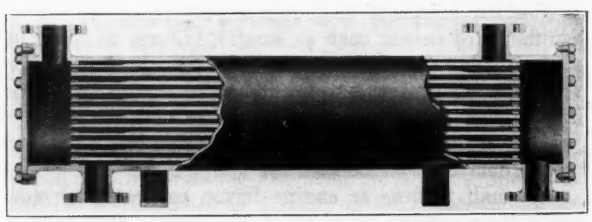
HERETOFORE baffles have usually been considered essential in heat exchangers to secure intimate contact between the liquid in the shell and the outside of the tubes. Such baffles many times cause collections of dirt, which at best is difficult to remove.

To overcome this difficulty and to increase the amount of surface in a given size of shell, The Griscom-Russell Co., 285 Madison Ave., New York, has designed, and applied for patent on, the G-R Equaflo Exchanger shown in the accompanying illustration.

Distinctive feature of this apparatus is the use of tubes swaged down at one end, to permit closer spacing of the tubes in the shell and, at the same time, to retain sufficient bridge wall in the tube sheets for strength.

The resulting design development of this unit is the elimination of cross baffles in the shells. In fact, the exchanger receives its name Equaflo because the tubes are so spaced in the shell that the area of flow through the shell may be equal to the area of flow through the tubes. This result is the ideal that has always been striven for by heat exchange designers.

The G-R Equaflo Exchanger is applicable to heat

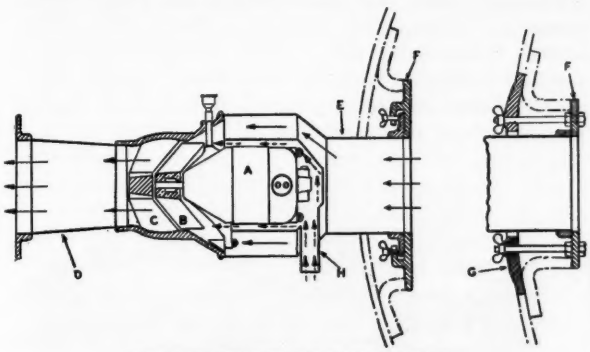


CUTAWAY VIEW OF EQUAFLO EXCHANGER SHOWING SWAGED TUBES

exchange between any two liquids or for use as a condenser or cooler. It is furnished in various arrangements and materials for different service requirements. This apparatus should be of particular interest to engineers and superintendents of petroleum refineries, natural gasoline recovery plants, chemical plants, etc.

Coppus Manhole Exhauster

DESIGNED for exhausting air or gases from boilers or tanks, the Coppus Manhole Exhauster shown herewith has recently been placed on the market by Coppus Engineering Corp., Worcester, Mass. As an aid in maintenance and inspection, rapid cooling and ventilating of boilers, furnaces, kilns, retorts, cracking stills and similar equipment is a great convenience and often a necessity. The manhole exhauster, it is stated has had many such applications.



COPPUS MANHOLE EXHAUSTER

The exhauster consists of a motor A, fan B, guide vanes C, diffuser D, inlet thimble E, manhead plate F, yoke G and air cooling pipe for the motor. Air is discharged as shown by the arrows.

The exhauster weighs about 90 lb., therefore it can be handled and put in place by one man, it is stated. It is built for manhole sizes 11 by 15 in. and 12 by 16 in.

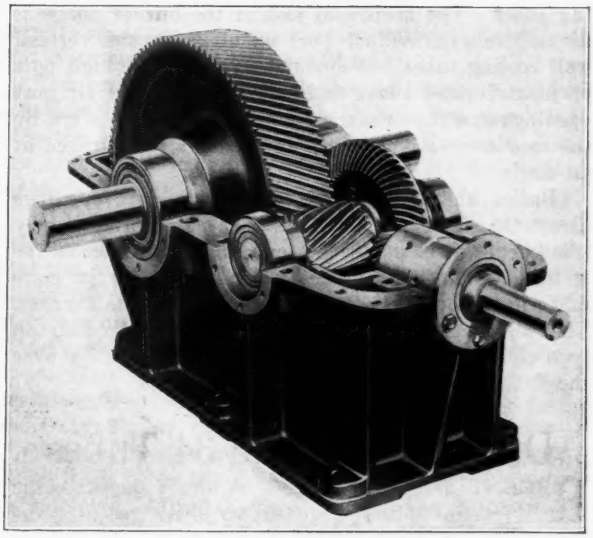
As the flange on diffuser D has the same dimensions as the one attached to inlet thimble E, the machine can be reversed and the flange of D attached to plate F. The fan will then act as a blower.

Right-Angle Drive Speed Reducer

TO SUPPLEMENT its line of parallel shaft drives, The Falk Corp., Milwaukee, Wisc., has brought out a line of right-angle drive speed reducers. The new line includes both horizontal and vertical shafts.

One feature of the Falk right-angle drive is a combination of single helical and spiral bevel gears. It is pointed out that single helical gears for the final reduction are easier to assemble than herringbone gears and that their efficiency is practically the same. An accurately cut single helical gear in combination with a high-grade spiral bevel makes a quiet, cool running reducer which has an initial efficiency of well over 95 per cent, it is stated.

Another feature is the reversible construction of gears and shafts. If the gears become worn after long service, shafts can be turned end for end to permit using the opposite and unworn sides of the teeth.



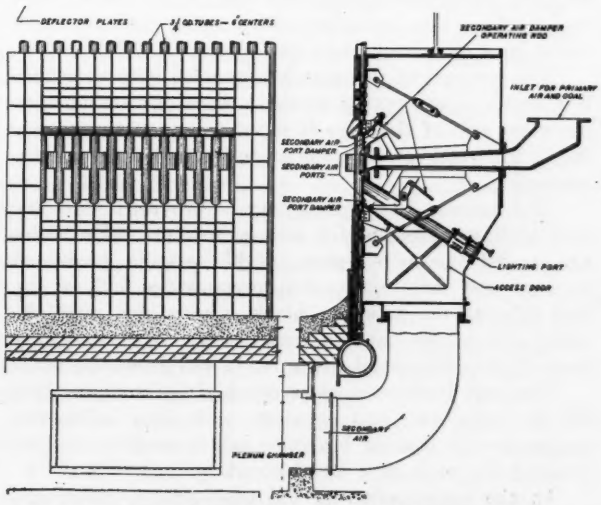
RIGHT-ANGLE DRIVE SPEED REDUCER

Ratings on the new line range from $\frac{1}{16}$ hp. per 100 r.p.m. on the smallest unit to 565 at 100 r.p.m. on the largest. Ratios are from 1.5:1 to 518:1.

Lubricating system of Falk right-angle units is designed to be simple and self-contained. A continuous splash system is provided to keep a film of oil on the working faces of gear teeth at all times. Complete line of welded steel motor beds has been developed to accommodate all motors coming within the capacities of the reducers.

Cross-Tube Turbulent Pulverized Coal Burner

FULLER LEHIGH cross-tube burner, shown herewith, is a turbulent type of pulverized coal burner recently developed for application to the Bailey furnace wall construction. Primary air and coal enters the furnace through a nozzle horizontally on the wall cool-



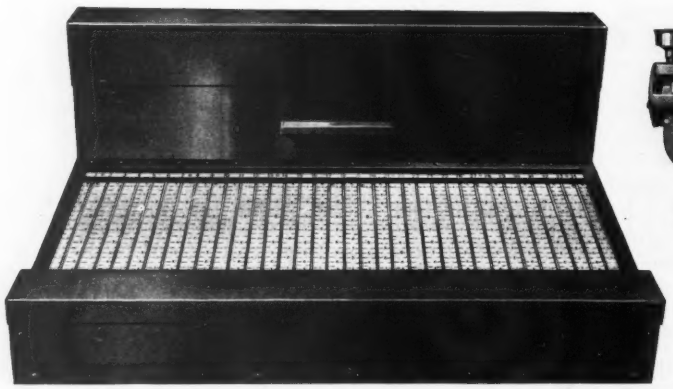
PLAN AND ELEVATION OF CROSS-TUBE TURBULENT POWDERED COAL BURNER

ing tubes. The horizontal slot in the burner nozzle is divided into individual port openings by the vertical wall cooling tubes. Secondary air enters through port openings located above and below the primary air port openings and the primary air and coal stream is cut by the secondary air streams, which enter the furnace at an angle.

Baffles ahead of the secondary air port openings direct the secondary air flow. The flame produced by this burner, it is stated, is evenly distributed across the width and breadth of the furnace, resulting in more uniform combustion conditions throughout the furnace. This burner is particularly applicable to the slag-tap type of furnace to insure uniform heat distribution over the flat furnace floor.

Draft Gage With 34 Tubes

RECENT DEVELOPMENT in draft gages is the 34 inclined tube gage shown here, recently designed by Lewis M. Ellison and built by the Ellison Draft Gage Co., Chicago, Ill. It comprises two units for the new forced-draft type Taylor stokers for the Beacon Street plant of the Detroit Edison Co.



ELLISON 34-TUBE DRAFT GAGE

Each stoker is equipped with 34 venturi nozzles in a common wind-box, pointing up towards the grate. In each nozzle is a damper for controlling the air flow to a uniform rate, as indicated by a straight line differential reading on the gage, one tube for each nozzle.

The zero end of the gage is connected with the wind-box under a common pressure. Each of the tubes at the other end of the gage is piped to one of the nozzles in the grate side of the damper and is sealed up to 6 in. pressure.

The scale is 10 in. long and is provided with one inch sliding movement for zero adjustment. The tubes are spaced one inch centers, with the scale graduated to read one inch differential pressure in 0.01 in. on one side of the tube, in black graduations, and the other side of the tube to read the air flow, or square root of the differential pressure, in red graduations.

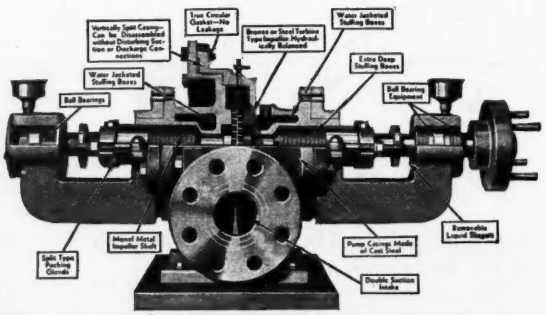
The gage frame was constructed of ¼-in. brass plate, 36 in. wide, and was provided with four adjustable supports with floating bearings, one in each corner, for leveling the gage on a metal stand.

In the construction of the gage frame, great care was exercised to minimize weaving of the frame and to provide means for placing the gage in the same position, with reference to tube inclination, in which it was standardized.

Each of the four sides was provided with a datum or leveling surface, on which the gage is leveled with precision by a sensitive portable bench level, to eliminate fixed level breakage. In calibration of the 68 tubes at ¼-in. intervals, nearly all points checked exactly, none having an error exceeding 0.005 in.

Single-Stage, Double-Suction Pump

NEW DESIGN of the Westco turbine pump, manufactured by the Westco-Chippewa Pump Co., Davenport, Iowa, has recently been developed. These pumps are designed for circulating, boiler feed, booster service, refrigerating units, creameries, oil refineries and the like. They are built in sizes from 5 to 250 g.p.m. capacity and are designed to operate efficiently against pressures from zero to 250 lb.



SECTIONAL VIEW OF SINGLE-STAGE WESTCO PUMP

Westco turbine pumps are built in single stage only; it is claimed that the turbine principle provides efficient performance against high heads without the complications of multi-stage construction. The impeller is the only moving part, a machined and balanced vane-edged disk which operates in an open channel and without contact with the pump casing. Complete absence of metal to metal contact is stressed by the manufacturer as a feature to prevent wear and insure long pump life. The pump is double suction type, hydraulically balanced, to eliminate side thrust.

Intake and discharge openings are both on the periphery. The impeller shaft is of monel metal, carried on two outboard ball bearings, each provided with a grease cup. Further operating advantage claimed for Westco pumps is that they possess an unusually wide operating range and that it is not necessary to calculate the pumping head closely when figuring an installation. Rather, it is only necessary to determine the maximum head, it is stated; then, no matter how much less the head may actually be, the pump will deliver only slightly increased volume and power requirements will decrease with the head, thus insuring against motor overload.

The latest development has been the use of these pumps to provide forced water circulation in Riley-LaMont water walls. In all installations of these water walls to date, Westco turbine pumps have been used.

Heating and Ventilating Engineers Meet at Philadelphia

WITH AN ATTENDANCE of over a thousand members and guests, the 36th annual convention of the American Society of Heating and Ventilating Engineers held at the Benjamin Franklin Hotel in Philadelphia, Jan. 27 to 30, was one of the most successful in the history of this society. This year the meeting was doubly interesting because of the first International Heating and Ventilating Exposition which was held in the Exhibition Hall of the Philadelphia Commercial Museum at the same time. At this exposition, the products of over 300 manufacturers of heating and ventilating equipment were shown.

The meeting proper was characterized by a number of timely papers and reports of technical interest. One of the outstanding events of the sessions was the adoption of a unit heater code. This code had been framed by a committee of the society after two and a half years' work and was considered by members of the Unit Heater Association before it was presented to the society. The standardization to be obtained from the use of the code should be helpful in all branches of this method of heating. The great increase of unit heaters and the enlarged interest in this branch of the industry were amply demonstrated at the exposition. Many unit heaters were exhibited. Oil heaters and gas heaters also came in for a full share of attention.

Among the papers of interest to power engineers was a paper presented by L. A. Harding on "Power from Process and Space Heating Steam." This paper discussed the problem of obtaining a balance between the heat in the process steam available and the heat equivalent of the power requirements. The heat available per lb. of steam, according to Mr. Harding's paper, may be increased by increasing the initial pressure, by superheating, and by decreasing the back pressure. The comparative effect on the basis of per cent gain from initial conditions of 135 lb. dry saturated steam exhausting to process at 40 lb. was given in charts accompanying the paper.

Other papers of interest were: Pressure difference across windows in relation to wind velocity, by J. E. Emswiler and W. C. Randall; Air infiltration through various types of brick wall and construction, by G. L. Larson, D. W. Nelson and C. Braatz; Preventing condensation on interior building surfaces, by Paul D. Close; Measurement of the flow of air through registers and grilles, by Prof. L. E. Davis; Pipe sizes for hot water heating systems, by Elmer Smith and F. E. Giesecke, and Panel warming, by L. W. Fowler. This last paper was of particular interest. It treated of a system which seems to be becoming popular in England and consists of installing pipe coils of ½ to ¾-in. diameter in ceilings or walls of buildings. Water at 120 to 130 deg. is circulated through them and the walls and ceilings are thus heated. This method, it is claimed, permits of lower air temperatures without discomfort and is supposed to be more healthful.

The research activities of the society came in for considerable attention and T. J. Duffield was appointed executive secretary of the Committee on Research. Ten per cent of the exposition revenue was donated to the society's research activities.

In the report made by J. C. Fitts, on the progress made by the Association of Thermal Research, he stated that this association, whose purpose is preventing duplication of research effort, has indexed 4000 pieces of literature dealing with thermal engineering.

Officers elected for the coming year were as follows: L. A. Harding, president; W. H. Carrier, first vice-president; Prof. F. B. Rowley, second vice-president, and C. W. Farrar, treasurer.

Members elected to the Council for three years include R. H. Carpenter, New York; John D. Cassell, Philadelphia; Alfred Kellogg, Boston, and John Howatt, Chicago. Those chosen for the research committee included C. W. Haynes, Philadelphia; W. T. Jones, Boston; J. F. McIntire, Detroit; F. N. Speller, Pittsburgh, and Prof. A. C. Willard, Urbana, Illinois.

The Advisory Committee of the Exposition consisted of H. P. Gant, Chairman, York Heating & Ventilating Corp.; A. S. Armagnac, Heating and Ventilating Magazine; D. S. Boyden, Edison Electric Illuminating Co. of Boston; W. H. Carrier, Carrier Engineering Corp.; A. C. Edgar, Certified Heating Association, Inc.; Roswell Farnham, Buffalo Forge Co.; C. V. Haynes, Hoffman Specialty Co.; E. B. Langenberg, Langenberg Mfg. Co.; J. I. Lyle, Carrier Engineering Corp.; J. F. McIntire, United States Radiator Corp.; H. C. Murphy, Reed Air Filter Co.; F. R. Still, American Blower Co.; E. K. Webster, Warren Webster Co., and H. L. Whitelaw, American Gas Products Co.

Management and Materials Handling Meetings

WITH A SLOGAN Organizing for Permanent Prosperity the National Management Congress, the National Industrial Equipment Exposition and the National Materials Handling Convention of the American Society of Mechanical Engineers will hold sessions at the Stevens Hotel, Chicago, March 3–7. Robert Isham Randolph, president of the Chicago Association of Commerce, will act as chairman of the opening session of the congress.

Management sessions will be March 3 to 5, the exposition, March 3 to 7 and the materials handling meetings March 5 to 7. An Industrial Marketing Conference also will meet March 5 and 6 at the Blackstone Hotel under the auspices of the Industrial Marketing Division of the American Management Association.

Exhibits will cover material handling equipment, plant construction materials, power transmission, management production control, packaging, lighting, sanitation, lubrication and general labor.

Inspection trips have been arranged to plants including the Western Electric Co., Hawthorne Works, W. F. Hall Printing Co., Edison Electric Appliance Co., Swift & Co., Inland Steel Co. at Indiana Harbor, Whiting Corp. at Harvey, State Line Generating Station, and the Chicago Underground Tunnel.

Wednesday, March 5, at 7 p. m., a banquet will be held with Dexter Kimball and L. W. Wallace as speakers.

Management, Waste Elimination and Distribution Methods will be considered in Monday afternoon and evening meetings. Plant Maintenance and Management will occupy attention Tuesday. On Wednesday morning, Machines in Industry will be the topic. Conveyors and Materials Handling will be considered in Thursday and Friday meetings.

At the Industrial Marketing Conference, Blackstone Hotel, March 5 and 6, the topics, in the order in which they will be discussed, are: Channels of Distribution and Purchase, Forecasting Industrial Sales, Trends in Industrial Advertising and Sales Promotion, What Is Around the Corner in Industrial Marketing, Industrial Marketing Research, Compensating Industrial Salesmen, and Managing Industrial Sales Forces.

Further details can be obtained from the National Industrial Exposition, 308 W. Washington St., Chicago, Ill.

News Notes

To ASSIST in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains 14 Research Graduate Assistantships in the Engineering Experiment Station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry. Appointment is made and must be accepted for two consecutive collegiate years of 10 mos. each, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Half of the time (approximately 900 clock hours for each ten-month period) is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study. Nominations are made from applications received by the Director of the Station each year not later than the first day of April. Nominations are based upon the character, scholastic attainments, and promise of success in the principal line of study or research to which the candidate proposes to devote himself. Preference is given those applicants who have had some practical engineering experience following the completion of the undergraduate work. Appointments are made in the spring, and they become effective the first day of the following September. Additional information may be obtained by addressing The Director, Engineering Experiment Station, University of Illinois, Urbana, Illinois.

THROUGH ITS Applied Mechanics Division, The American Society of Mechanical Engineers will participate in the Third International Congress of Applied Mechanics to be held in Stockholm from August 24 to 29, 1930. The division has appointed a special committee, of which Dr. S. Timoshenko is chairman, to take care of the details, in connection with its part in this Congress. The field of interest of this coming convention lies in hydrodynamics and aerodynamics, theory of elasticity, and rational mechanics. The Applied Mechanics Division of the Society is also arranging a tour of the most important European laboratories in mechanics. Following the Stockholm Congress, there will be a congress on general mechanical engineering to be held in Liege, Belgium, from August 31 to September 7, which is being held at the same time as the Belgium International Exposition of Trades and Manufacturers, Sciences and Their Application.

NATIONAL CONFERENCE for Home Service Directors will be held at the Palmer House, Chicago, March 6, 7 and 8, 1930. This program has been arranged by the Home Service Subcommittee, Women's Committee, N. E. L. A., of which Miss Ada Bessie Swann is chairman, to give Home Service workers for the first time an opportunity to hear and participate in discussions of all problems affecting their work.

P. H. & F. M. ROOTS Co. has merged with other interests and is now under the control of the Stacey Engineering Co. of Columbus, Ohio. The new organization includes The P. H. & F. M. Roots Co. and The Connersville Blower Co., both of Connersville, Ind.; The Wilbraham-Green Blower Co. of Pottstown, Pa., and the Stacey Brothers Gas Construction Co. of Cincinnati, Ohio.

Heading the list of officers, Colonel Carmi A. Thompson of Cleveland was elected president; Corwin Abbott, vice-president and general manager; Fletcher S. Heath of Columbus, Ohio, vice-president, and Erle G. Meeks, secretary and treasurer. Charles T. Gordon will continue as general superintendent.

E. D. Johnston, for the past 45 yr. with The P. H. & F. M. Roots Co., has resigned as president of the company and has retired from active business.

The new board of directors consists of Colonel Thompson, F. S. Heath and C. A. Ward of Columbus, Ohio; W. B. Stacey of Cincinnati, J. T. Wilkin, Corwin Abbott and Charles T. Gordon of Connersville.

All companies involved in the merger will maintain their separate identities and organizations, and will continue to operate separately until the final plans of the merger can be consummated.

D. H. SKEEN & Co. announces the removal of its offices on March 1 from the Monadnock Building, 53 West Jackson Blvd., to Room 1855, One La Salle St., Chicago, Ill.

JOSEPH J. MULLAN has recently been appointed New York manager for Elliott Co., Jeannette, Pa., and associates. Mr. Mullan has for the past year been in the New York office of the company as condenser specialist.

A. N. CARTWRIGHT, general superintendent of operations, West Penn Power Co., Pittsburgh, has been promoted to operating vice-president in charge of all maintenance and engineering having to do with generation, transmission and distribution. Mr. Cartwright has been with West Penn since July, 1903, having charge during this time of various engineering and construction activities.

A. N. CARTWRIGHT

Previous to his connection with West Penn Power Co., Mr. Cartwright was with the Lonaconing Electric Light Co., Lonaconing, Maryland, from 1898-1900; The Consolidated Coal Co., Ocean, Maryland, 1900-1901; Camden Interstate Railways Co., Ashland, Kentucky, 1901-1902, and from 1902 to 1903 with the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pennsylvania.

SINCE February 10, the Detroit district sales office of Cutler-Hammer, Inc., Milwaukee, Wisc., has been located at 2755 East Grand Boulevard, Detroit, Mich. The new location includes warehouse facilities.

CONSOLIDATED Gas, Electric Light & Power Co. of Baltimore, Maryland, has purchased a 30,000-kv-a. frequency changer from the Westinghouse Electric and Manufacturing Co. The machine will be installed at the company's Westport station. It will be used as a connection between the present 60 and 25-cycle systems and is designed to operate at 300 r.p.m.

TENNESSEE ELECTRIC POWER Co. will install a 25,000-kv-a. vertical, water-wheel generator, purchased from the Westinghouse Electric and Manufacturing Co., in its Blue Ridge station, to be used in connection with hydroelectric development in the northern part of Georgia. This machine, of the new umbrella type, will operate at 164 r.p.m.

WESTINGHOUSE ELECTRIC & MANUFACTURING Co. has recently received an order from the Edison Electric Illuminating Co. of Boston, Massachusetts, for two 13,000-amp., 60-cycle booster converters, with air blast transformers and starting and running breakers. These machines are to be used in addition to the present equipment for supplying additional power to the Edison d.c. system. One machine will be installed in the company's Arch St. substation and the other in the Carver St. substation.

STUART M. CROCKER, who on January 1 resigned his position as vice-president and treasurer of the United Electric Securities Co. to become assistant to the president of the International Gen-

eral Electric Co., has been elected a vice-president of the latter company, President Clark Minor has announced. Mr. Crocker, a graduate of Harvard University, was assistant to Owen D. Young, chairman of the board of the General Electric Co. and Radio Corp. of America previous to his position with the securities company. In 1924 he accompanied Mr. Young to Europe as secretary of the American delegation to the Experts Conference which culminated in the Dawes plan. In 1928 he also accompanied Mr. Young abroad in connection with the Paris Reparations Conference which formulated the Young plan. Mr. Crocker's office will be at 120 Broadway, New York.

FREDERICK ALAN SCHAFF has been elected president of The Superheater Co., George L. Bourne, retiring president, having been elected Chairman of the Board of Directors. Mr. Schaff's headquarters will remain at the principal office of the company, located at 17 East 42nd St., New York, N. Y. Mr. Schaff was born at Nelsonville, Ohio, on May 24th, 1884, and was graduated from Purdue University in 1907, following which time he spent several years in the Mechanical Department of the Boston & Albany R. R. and New York Central Lines. After several years' residence in Texas, in charge of business interests there, he became associated with The Superheater Co., in its service department, in 1913 and was elected vice-president in 1915, in which capacity he has served the company until his recent election to the office of president.

ON FEBRUARY 1, 1930, A. E. Moeller Co. of 261-265 Sumpter St., Brooklyn, N. Y., was succeeded by the Moeller Instrument Co., Inc. The active ownership and management will remain the same as for many years past under the following personnel:

Charles E. Moeller, president and general manager; Max E. Moeller, vice-president and head of research department; Curt F. Moeller, treasurer and factory manager; Paul G. Moeller, secretary and charge of sales department; Otto J. Moeller, asst. treasurer and glass production department; Walter G. Moeller, production department.

TWO-REEL MOTION PICTURE telling the story of Monel Metal has been released by the Rothacker Film Corp. of Chicago. The film shows the preparation of the metal in its various commercial forms at Huntington, West Virginia, and traces its various uses in more than a score of different industries. Also shown in the film is the tapping of an 11-t. furnace with the molten metal being poured at a temperature of 3000 deg. F. The picture is being offered to schools, societies, commercial organizations, and the like without charge and is available in 35-mm. and 16-mm. widths.

M. F. CORIN, who for 14 yr. has been Philadelphia district sales manager for The Permutit Co., New York, has been appointed general sales manager. He will have supervision over 19 branch sales offices throughout the United States and numerous sales agencies in foreign countries. He will assume his new duties at The Permutit Co.'s main office in New York sometime during February.

ANNOUNCEMENT is made by Reading Chain & Block Corp., Reading, Pa., of the appointment of W. J. Zink, as its representative for Alabama and vicinity. Mr. Zink will operate from Homewood Station.

LINK-BELT, LIMITED, recently opened a branch office in the Standard Bank Building, 510 West Hastings St., Vancouver, with Frank B. Wetherill in charge. Mr. Wetherill joined the Link-Belt organization 15 yr. ago and, for a number of years, has been manager of the company's office and warehouse in Portland, Ore. In establishing this new office, it is aimed to supplement the service which has been rendered through Fleck Bros., Ltd., Canadian Fairbanks-Morse Co., Ltd., and A. R. Williams Machinery Co., Ltd., who will continue as official distributors of Link-Belt Chain and other merchandise material.

AT THE ANNUAL MEETING of the Harshaw Chemical Co., Cleveland, Ohio, held on February 6, William B. Lawson was elected a director and at the organization meeting of the board of directors held February 7, he was elected a vice-president. For many years Mr. Lawson has been connected with The International Nickel Co. with headquarters in the executive offices, New York City.

CHICAGO OFFICE of The Griscom-Russell Co., New York City, after March 1, 1930, will be Room 1442, 20 North Wacker Drive, Chicago, Ill.

ANNOUNCEMENT is made of the death, on January 17, of Clarence W. Hodges, general purchasing agent of the Worthington Pump & Machinery Corp., 2 Park Ave., New York. Seemingly enjoying the best of health, Mr. Hodges was taken suddenly ill and died at the Paterson, N. J. Hospital as a result of an operation. He was 53 yr. old. Mr. Hodges was born at Randolph, Vt., May 15, 1876, and was graduated from Williams College with the class of 1900. For some years he was employed by the American Locomotive Co. as purchasing agent and since 1918 he had been employed in the same capacity by Worthington.

ACCORDING TO a recent statement by the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce, Washington, D. C., an attempt will be made, in taking the 1930 decennial census, to secure figures that may serve as a gage of economic status and buying power more accurately than obtained by any previous census. Data to be secured for the first time include information on the value of the home, if owned, or monthly rental, if rented. In previous censuses, data have been obtained on the occupation of each gainful worker, the industry in which he is employed and whether he is employer or employee. In the 1930 census, however, an attempt will be made to determine whether each person usually employed is actually at work or not. If not, additional information will be secured on a special unemployment schedule. The schedule also asks whether the home has a radio set. The information on the number of receiving sets in use in the country is expected to give an accurate basis for the number of listeners and to assist the Federal radio to authorities in apportioning facilities on that basis.

Books and Catalogs

FOURTH EDITION OF THE TRADE STANDARDS of The Compressed Air Society has just been published, and copies may be had upon application to C. H. Rohrbach, Secretary, 90 West St., New York; price, 50 cents each. New material in the pamphlet includes a new formula for use in air compressor testing, accurate for higher water columns than that previously used, thereby extending the capacity of a nozzle of a given size through a greater useful range; further suggestions in connection with the installation and operation of air compressors; caution against the use of old boilers or tanks as air receivers; suggestion for handling extremely cold cooling water to prevent condensation and undue wear on the air cylinders; and another illustration of an air cleaning device.

NYGAARD WATER WALL BLOCKS are described and their applications illustrated in a 12-page illustrated bulletin issued by Bernitz Furnace Appliance Co., 89 Broad St., Boston, Mass. The bulletin shows the various shapes and sizes of blocks provided, describes the method of installing them in water walls and shows by illustrations various types of furnaces to which they can be applied.

PULVERIZED FUEL is the subject of N.E.L.A. Publication No. 06, just issued as a report of the Prime Movers Committee, Engineering National Section, N.E.L.A., 420 Lexington Ave., New York, N. Y. This report states that a decided trend to unit mill installations is shown for both industrial and public utility plants. Tables are included showing detailed preparation costs and boiler equipment performance. Boiler operation and maintenance methods are described. The following trends and practices are reported: Increased use of water walls; new types of burners resulting in improved performance; success with mill drying; solutions of vent problems; small range in burner capacity; automatic control shows improvement over hand control, but is not in wide use.

ROLLER CHAIN and Drive Data are given in a booklet issued by the Link-Belt Co. of Chicago, Ill., with engineering information to enable the selection of the correct drive for any purpose and figuring the cost. Distributors, who carry the chain and wheels in stock are also listed, so that orders can be placed for quick delivery from a nearby point.

STEPHENS-ADAMSON MFG. CO. of Aurora, Ill., has issued an attractive 16-page catalog describing its new vibrating screen and giving construction details, dimensions, capacity data and installation photographs. It is unusually well printed in four colors and describes features of the new screen, including grid type support for screen cloth; suspension mounting for sub-base; quick action clamps for screen changes and a self-contained vibrator mechanism which can be removed as a unit from the screen body.

POWER PLANT and Oil Refinery Equipment is the title of a new catalog just issued by the Key Boiler Equipment Co. of East St. Louis, Ill. The catalog illustrates and lists a wide variety of refinery fittings, tube-rolling tools, air motors, metal gaskets, joint sealing compounds and the like. Illustrations show actual installations of Key Safety Hand Hole Caps. The catalog is bound in loose-leaf style with an artistically designed cover.

CAPACITORS FOR POWER FACTOR Correction, is the title of Circular No. 1670-B, a recent publication of the Westinghouse Electric & Manufacturing Co. This circular briefly discusses the causes of low power factor and means of correcting it. Pictures of installations and examples of the decreased costs obtained by several companies using these capacitors make this circular of particular interest to power consumers.

BROWN INSTRUMENT CO., Wayne and Roberts Aves., Philadelphia, Pa., is issuing a new catalog, No. 7501, describing a new instrument of remote indicating and recording type for pressures, liquid levels, flows and positions of valves or other controls.

Power Plant Construction News

Ark., Warren—The Warren Cotton Oil Mfg. Co., is planning extensions and improvements in ice and refrigerating plant, including installation of additional equipment.

B. C., Vancouver—The Pacific Mills, Inc., Standard Bank Building, Vancouver, plans installation of electric power equipment in proposed paper mill at Burrard Inlet, entire project to cost close to $150,000.

Colo., Fort Lupton—The City Council has rejected bids, recently received, for a Diesel-engine pumping unit for the municipal waterworks, and is said to be plannning for call for new bids at an early date, with unit to have a capacity of 12,000 gal. per min.

D. C., Washington—The Potomac Electric Power Co., Fourteenth and C Streets, is completing plans for a five-story equipment storage and distributing plant, with meter department and other mechanical divisions, estimated to cost more than $200,000. A. B. Heaton, 1211 Connecticut Avenue, N. W., is architect.

Ga., Savannah—The United Shank & Findings Co., 89 Beach Street, Boston, Mass., plans installation of electric power equipment in proposed new plant at Savannah, entire project reported to cost about $100,000.

Ind., Indianapolis—The Marmon Motor Car Co., 1101 West Morris Street, is considering construction of a one-story steam power house, primarily for heating service, reported to cost more than $40,000, with equipment.

Ind., Valpariso—The Board of Trustees, Valpariso University, has preliminary plans under way for a one-story power house for heating service, reported to cost more than $35,000. Miller & Wallace, 222 West Adams Street Chicago, Ill., are architects and engineers.

La., Bunkie—The Louisiana Ice & Utilities Co., Bunkie, plans extensions and betterments in local ice-manufacturing plant, including installation of additional equipment, reported to cost about $30,000.

Md., Baltimore—The Gulf Refining Co., Frick Annex, Pittsburgh, Pa., will build a one-story boiler plant at proposed storage and distributing plant for oil service at Fairfield, Baltimore, entire project to cost $140,000.

Miss., Ripley—The Ripley Utilities Co., is planning extensions and improvements in local ice-manufacturing plant, with installation of equipment to double present capacity, reported to cost more than $35,000.

Mo., Mexico—The Mexico Refractories Co., Greer Building, Mexico, recently organized, plans installation of electric power equipment in proposed firebrick manufacturing plant, entire project reported to cost close to $100,000. J. B. Arthur, heads the company.

Neb., Falls City—The Tolerton & Warfield Co., Sioux City, Iowa, is said to be planning the installation of electric power equipment in proposed new canning plant at Falls City, entire project to cost more than $75,000.

Neb., Lincoln—The State Board of Control, State House, Lincoln, has plans under way for power plant on local site, reported to cost about $60,000. The Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is engineer.

N. J., Newark—The Eberhard Faber Rubber Co., Hoyt Street, plans installation of electric power equipment in proposed four-story factory addition, entire project to cost more than $100,000. The Enbro Corporation, 111 Academy Street, Newark, is architect and engineer.

N. Y., Amsterdam—The Mohawk Carpet Mills, Inc., Amsterdam, has preliminary plans under way for a boiler plant to cost more than $100,000, with equipment. C. W. Becker, Elm Street, Amsterdam, is architect and engineer.

N. Y., New York—The Department of Hospitals, Municipal Building, has plans under way for extensions and improvements in power plant at the Harlem Hospital, in connection with an expansion program at the institution. Sloan & Robertson, 420 Lexington Avenue, New York, are architects.

N. Y., Oneida—The Oneida-Kraft Co., Oneida, plans installation of electric power equipment in proposed four-story addition to furniture plant, entire project to cost about $200,000. It is understood that bids will be asked on general contract in March.

N. C., Greensboro—The Greensboro Full-Fashioned Hosiery Mills, Inc., plans installation of electric power equipment in proposed new plant unit, entire project to cost more than $125,000. Charles C. Hartman, Jefferson Building, Greensboro, is architect and engineer.

Ohio, Sharonville—The Cleveland, Cincinnati, Chicago & St. Louis Railroad, Ninth and Sycamore Streets, Cincinnati, Ohio, plans installation of steam power equipment in proposed engine house and shops at Sharonville, entire project to cost close to $100,000. H. A. Baldwin, address noted, is engineer.

Ore., Eugene—The Pacific Paper Products Co., care of A. A. Rogers, First National Building, recently organized by Mr. Rogers and associates, plans installation of electric power equipment in proposed new paper and pulp mill in this vicinity, entire project reported to cost $400,000. A boiler house is planned.

Ore., Gold Hill—The Beaver Portland Cement Co., Lumbermen's Building, Portland, is said to be planning a hydro-electric power plant on the Rogue River, near Gold Hill, for service at cement mill last noted place, reported to cost more than $250,000, with equipment. F. W. Allen, Railway Exchange Building, Portland, is engineer.

Ore., Portland—The Portland Electric Power Co., Electric Building, is planning extensions in steam-operated electric power plant, known as Station L, foot of East Lincoln Street, including installation of a watertube boiler and accessories, reported to cost more than $75,000.

Pa., Brackenridge—The Allegheny Steel Co., Brackenridge, Pittsburgh, plans installation of electric power equipment in connection with an expansion and improvement program at local steel mill, entire project reported to cost close to $500,000.

S. C., Greenville—The Planters' Fertilizer & Phosphate Co., plans installation of electric power equipment, in connection with proposed rebuilding of portion of mill, recently destroyed by fire with loss reported in excess of $250,000.

Tenn., Nashville—The City Council, Nashville, is said to be planning installation of additional equipment at the municipal electric light plant. Estimates of cost will soon be made and bonds voted.

Texas, Houston—The Davison Chemical Co., Baltimore Trust Building, Baltimore, Md., plans installation of electric power equipment in proposed fertilizer plant at Houston, Texas, for which work will soon begin, entire project to cost more than $350,000.

Utah, American Fork—The City Council is planning extensions and improvements in municipal waterworks, including installation of pumping machinery and auxillary equipment. Entire project will cost about $150,000. A. Z. Richards is city engineer.

Utah., Salt Lake City—The Utah Oil Refining Co., Salt Lake City, plans installation of electric power equipment, in connection with proposed extensions and improvements in oil refining plant to cost $150,000.

Wash., Yakima—The Washington Water Power Co., Spokane, and the Northwestern Electric Co., Portland, are planning construction of a joint transmission line from Yakima to White Salmon, about 80 miles, to operate at 110,000 volts. It is estimated to cost close to $1,000,000, including switching stations and facilities.

W. Va., Weirton—The Weirton Steel Co., Weirton, a division of the National Steel Corporation, plans installation of electric power plant equipment in proposed new rail mill at local steel works, entire project reported to cost close to $1,000,000.

Wis., Elroy—The City Council, Elroy, has authorized the installation of a Diesel-engine generating plant for municipal light and power service. E. E. Brintnall is city clerk.

Wis., Manitowoc—The Wisconsin Fuel & Light Co., has approved plans for the immediate construction of an addition to artificial gas plant, including boiler plant, reported to cost about $100,000.